# JOURNAL

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# National Council

The Society of Plastics Engineers, Inc., is a corporation! A non-profit organization incorporated under the laws of the State of Michigan in 1942. When one becomes a member of the Society, one becomes a member of the corporation. In order that everyone may have a voice in the affairs of the Society, each local section elects one man to serve on the Board of Directors for a term of three years. That man is the "voice" from the local section to the national organization as well as the representative of the national organization in local activities. His position is one of great importance to the smooth running of the Society. The decisions he makes at the national board meeting determine the entire policy of the Society and his interpretation of the actions of the national to his local section determines its interest in the Society.

Each year officers are elected for a term of one year from the Board of Directors. These men are the officers of the corporation and the representatives of the Society to all other groups. Their position in the Society is time consuming and often thankless. However, all the men who have ever served as officers have done the job to the best of their ability.

In order that every member may know, not only his own representative on the National Board of Directors, but also all the other men on it, their pictures and biographies follow. It is from this group of men that the 1950 officers were elected on January 11, 1950.


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WILLIAM R. BAILEY

R. B. BISHOP

GEORGE W. CLARK

ROBERT G. DAILEY

the Society in 1946 in the Eastern New England Section. When he moved to Texas, he helped organize the North Texas Section.

**RICHARD B. BISHOP**, Philadelphia Section, is in the Socony-Vacuum Laboratories, a division of Socony-Vacuum Oil Company, Research and Development Department, Paulsboro, N. J. He has been very active in Society activities for a number of years. He was president of the Philadelphia Club and was instrumental in that clubs becoming the Philadelphia Section of S.P.E. He served as president of the section in 1946, as National Director in 1947, as National treasurer in 1948, Chairman National Conference Committee in 1948 and Chairman National Credentials Committee in 1949. He has just been elected as treasurer of his section for 1950. He will be succeeded on the National Council by W. O. Bracken.

**WILLIAM O. BRACKEN**, Philadelphia Section, is a member of the plastics technical service division of the Cellulose Products Department, Hercules Powder Company. He graduated from Tufts College, Bedford, Mass. with a B. S. degree in chemical engineering. Immediately after he joined the General Chemical Company plant in Buffalo. He worked for a short time at Cambridge, Mass., plant of BB Chemical Company. He joined the Hercules Powder Company in 1939 as a chemist at the Experiment Station in Wilmington, Delaware, and later transferred to the laboratory of Hercules cellulose products plant at Parlin, N. J. He returned to Wilmington, Delaware as a member of the Hercules cellulose plastics marketing section, and later served as an assistant product supervisor. He is a member of ACS and SPI. Although active in his local section he has just become a member of the National Board of Directors.

**GEORGE W. CLARK**, Toledo Section, graduated from Rensselaer Poly. Inst. in Chemical Engineering and entered the field of plastics in 1923 with duPonts making pyroxlin coated fabrics and recovering solvent from production coating machines. He was supervisor of development of laminated plastics and insulating materi- with Westinghouse for eight years. He continued to develop laminated plastics with the Richardson Co. for a couple of years then left the laminating industry for the powder molding field. He is in his twelfth year with Owens-Illinois Glass Co. as Chief of the Plastics Section of the General Research and New Developments Division. He has lectured on plastics at the university of Toledo for four years. Mr. Clark has long been active in Society affairs, both local and national. He was National President in 1947. He is a subcommittee chairman in D20 ASTM, a member of SPI and ACS. He was made a Life Member of the Society for his work.

**ROBERT G. DAILEY**, Detroit Section, is a native of Michigan, receiving his B. S. in Mechanical Engineering from University of Michigan. Previous to founding his own company, Wolverine Plastics, Inc., Milan, Mich., he worked as a sales engineer for Firestone Plastics Division, Firestone Tire & Rubber Co.; as chief engineer and sales manager of the Plastics Division, Standard Products Co. Mr. Dailey has been active in the Society since its founding in Detroit. Besides many local offices he has been a Secretary of the National Organization and Chairman of the 1948 National Conference Committee.

**ROBERT L. DAVIS**, Central Ohio Section, is in the Plastics Division of Continental Can Company, Cambridge, Ohio. He received his B. S. in Industrial Engineering from Lehigh University in 1933. He was

ROBERT G. DAVIS

ALBERT DIETZ

J. HARRY DU BOIS

WILLIAM L. HESS

McEWEN

S. K. MOXNESS

WAYNE PRIBBLE

EARL A. RUSSELL

employed by the General Electric Company on a student training course and later in their Plastics Division. He studied at New York University and received his M.S. in Mechanical Engineering from Lehigh University in 1946. Mr. Davis has been very active in his section and served on the National Auditing Committee in 1949.

**JOHN DELMONTE,** Southern California Section, received his B. S. from New York University, College of Engineering and his M. S. from M. I. T. He has studied at University of Pennsylvania and Illinois Institute of Technology also. Prior to becoming General Manager of Furane Plastics and Chemicals Co., he worked as an engineer with Naval Aircraft Factory, Philadelphia; research engineer, Firestone Tire and Rubber Co.; assistant chief engineer, Sunbeam Electric Co.; instructor at Illinois Institute of Technology; and technical director of Plastics I. T. Institute. Mr. Delmonte has been active in the Society for several years and helped organize the Southern California Section of which he served as president during 1949.

**ALBERT G. H. DIETZ,** Eastern New England Section, is an Associate Professor of Structural Engineering at Massachusetts Institute of Technology in Cambridge. He received his A. B. from Miami University at Oxford, Ohio and his S. B. and Sc. D. from M. I. T. Mr. Dietz has also been active with P.M.M.A. and their program at M. I T.

**J. HARRY DU BOIS,** Director-at-large, is vice-president and executive engineer of Shaw Insulator Company, Irvington, N. J. After receiving his degree from the University of Minnesota, he joined the plastics department of General Electric Company, where he remained until 1944. He was vice-president of the Society in 1947 and president in 1948, and has been made a Life Member in appreciation of his work for the Society.

**NICHOLAS V. FASANO,** New York Section, started in the plastics industry at the age of sixteen. During the years, he has had experience in all departments from materials room up to finished product, covering practically all branches in the field. In 1940 he started the Washnigton Molding Company, Inc. and has acted as its president, directing production, sales, etc. The company, located in Port Washington, N. Y., does compression, injection and extrusion work of all varieties.

**J. H. FIELD, JR.,** Mexico Section, graduated from Dartmouth College with an A. B. in Chemistry. He joined the B. F. Goodrich Co. in Akron in September, 1939 as analytical chemist. He transfered to their Koroseal Research Department and was then appointed Technical Manager of the Plastics Development Laboratory for the newly formed Chemical Division. He moved to Cleveland with the Chemical Division, which became the B. F. Goodrich Chemical Company and became Technical Manager of the Plastics Materials Sales Division. In 1945 he resigned to become General Manager of Plastipos, S. A., a newly formed wire and cable and flexible extrusions plant outside of Mexico City. He became a member of the Society before going to Mexico, being a charter member of the Cleveland Section. He assisted Mr. Thomas E. Orr in forming the Mexican Section and served as its secretary and president, the later position he is still holding by request of the section membership.

**M. S. GREENHALGH,** Connecticut Section, was educated at the University of Bridgeport, majoring in chemical engineering. He joined the General Electric Company at Bridgeport in 1933 and was transferred to the laboratory in 1935 where today he is section engineer in charge of plastics. In 1948 he won the Charles A. Coffin award given by GE for out-

MARION A. ARTHUR

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NICHOLAS FASANO

HAROLD L. LEVEY

WILFRED LYNCH

GEORGE A. PECK

standing contribution in advancement of his work. For the past ten years he has been professor of chemistry at the University of Bridgeport in the Evening Division where he has lectured on plastics and rubbers and conducted classes in chemistry. He is a member of ACS. He is president of his local section.

**WILLIAM L. HESS**, Chicago Section, is Vice-President and Chief Engineer of Anesite Company, Chicago, and has been in the thermoplastic extrusion field since 1941. With his brother George, he founded Anesite Company in April 1946. Previously he was production manager for Midwest Plastic Products Co. and Sandee Mfg. Co.

During the years 1932 to 1940, he held supervisory positions in production and engineering of compression molded wood fibre plastic products in the Chicago and Traverse City, Michigan, areas.

He attended Crane Jnior College and the University of Chicago, and majored in Mechanical Engineering.

Hhe was a charter member of the Chicago Section of S. P. E., and served for several years as chairman of the Technical Committee. For two years Hess was National Vice-Chairman of S. P. E. Technical Activities. He was elected a director of the Chicago Section in 1946, and served as President during 1948. From 1943 to 1945, he was chairman of Sub-Committee IX on Molds and Molding Processes, D-20 Plastics Committee, American Society for Testing Materials.

**H. J. KASCH, JR.**, Miami Valley Section, graduated from Purdue University in Mechanical Engineering. He worked in Production Control Department for Toledo Scales Company and then joined the sales staff of Kurz-Kasch, Inc. He worked in various capacities for the company and is now a sales representative for Kurz - Kasch, Inc. and Standard Moulding. Mr. Kasch has been very active in his local group for some time.

**HAROLD L. LEVEY**, New Orleans Section, is a past vice president of the American Chemical Society. He holds an M.S. in Chemistry from University of Illinois and an honorary degree in chemical engineering from Tulane University, where he did his undergraduate work. He is president of American Products Mfg. Co., Inceloid Company, Inc. and an independent chemical engineering consultant. He is active in many chemical, engineering and scientific societies.

**WILFRED LYNCH**, Quebec Section, has ten years experience in production and process engineering in the plastics industry. He has just recently became technical manager of Maple Leaf Plastics, Ltd., Toronto, Ontario. Mr. Lynch has transferred to the newly organized Toronto, Ontario Section so will not be serving on the Council this coming year.

**F. W. McEWEN** of the newly formed Ontario Section was born in New Liskeard, Ontario. He was graduated from Faculty of Applied Science and Engineers at the University of Toronto in 1937 with a B.S.C. Degree in Mechanical Engineering. On leaving school he went to work for Duplate Canada, Ltd., as an assistant to the plant engineer. The same year he joined Duplate they went into the plastics business and part of his job was to set up a compression and injection molding plant.

During the war Mr. McEwen served in the Canadian Army with the Royal Canadian Electrical and Mechanical Engineers. Upon leaving the army he returned to Duplate as the Superintendent of the Plastics Division which had grown to include the following phases of plastic operation: Compression Moulding: In-

N. R. REYBURN

ISLYN THOMAS

JOHN G. ROBB

jection Moulding; Extrusion; Fabricating; Low Pressure Laminating.

Mr. McEwen's main hobby is his membership in the Reserve Army which corresponds to the National Guard in the United States.

**S. K. MOXNESS**, Upper Midwest Section, is chief process engineer of Minneapolis - Honeywell Regulator Co., Minneapolis. He has studied machine design at the University of Wisconsin and was an instructor in tool engineering, plastic mold and die casting at the University of Minnesota. Prior to his present position, he was an engineer and assistant chief tool designer for his company. Mr. Moxness has been a member of the Society since 1943 and has been active both locally and nationally.

**GEORGE A. PECK**, Rochester Section, has a degree in Chemical Engineering from Clarkson College of Technology, Potsdam, N. Y. He has worked in the Research Department of General Cable Corporation, Rome, N. Y. and was Head of Chemical Research at the Upsom Company, Lockport, N. Y. In June of 1942 he was employed by Stromberg - Carlson Company as Engineer in Charge of Materials Laboratory. In August 1949 he became their Assistant Manager of Production Engineering, Radio and Television Division. He is a member of the American Institute of Chemical Engineers, American Chemical Society as well as the S.P.E.

**WAYNE I. PRIBBLE**, Northern Indiana Section, served his apprenticeship with the Fort Wayne Division of General Electric Company and graduated as a toolmaker in 1937. He went to work in the Plastics Division at Fort Wayne Works where he designed practically all the molds made for that division between 1937 and 1941. In 1941 he became Product Engineer in the same Plastics Division and in 1948, with Alvis L. Barrier, organized the consulting engineering firm of Barrier-Pribble & Co., Inc. to specialize in mold design, consultation on molding and methods. Mr. Pribble is a registered professional engineer in the state of Indiana. He is president of the Northern Indiana Section and chairman of the National Committee on Mold Design, of S. P. E.

**N. R. REYBURN**, Northwestern Pennsylvania Section, has his B.S. from Yale University. He worked in plastics molding research with the American Cyanamid Company from 1937 to 1945. Since 1945 he has served as Chief Engineer of Applied Plastics Division of Keystone Brass Works in Erie, Pa. He has held several of the offices in his local section along with being a National Director.

**JOHN G. ROBB**, Golden Gate Section, is a plastics engineer with the American Molding Co. of San Francisco. He has worked as a mold designer for American Hard Rubber Co., Butler, N. J.; Eagle Tool and Machine Co., Newark, N. J., and Newark Die Co., N. J. He has been very active in his local section, being its first president when it was organized in 1948.

**EARL A. RUSSELL**, Buffalo Section, is now chief engineer of Spaulding Fibre Company. He graduated from Syracuse University as a Chemical Engineer and spent four years in plant engineering work in the heavy chemical industry before coming to Spaulding Fibre Company. For the past twenty-six years he has been engaged in plant production work, followed by engineering and development work in the two plastics, Vulcanized Fibre and Spauldite. Mr. Russell has been very active in both local and national activities of the Society and served as National Secretary in 1947.

**ISLYN THOMAS**, Newark Section, is president of the Thomas Engineering Corporation, Plastics Parts Development Corporation and General Manager of Thomas Engineering Company. He is a graduate of Johnson Tech. School, Plastics Ind. Tech. Inst., University of Scranton and Columbia University. He taught plastics and mold design at Polytechnic Institute of Brooklyn and was estimator, mold designer, sales engineer and manager of development during twelve years with Consolidated Molded Products Corp., also production manager of Ideal Novelty and Toy Co. and general works manager of Ideal Plastics Corp. Although being active in his local section activities, Mr. Thomas has just become active in national affairs of the Society.

**SHERWOOD L. YOUNG**, Western New England, is vice president of C. F. Church Mfg. Co. He joined the company in 1928 at their Washington, N. J. plant, in the cost department. He became plant manager of their molding division at Monson when the division was set up. Mr. Young has been very active in local section activities and has just become a member of the National Council.

S. L. YOUNG

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By WALTER KOSY

*Lyon Incorporated*

The Christmas party of the Detroit Section of the SPE was held at Adrian Cotter's Tavern in Berkley, Michigan, on December 16, 1949. Following the dinner, door prizes were distributed (courtesy of Mr. John Slater, Tennessee-Eastman Corp.) and then Mr. Paul Lillis of the Bakelite Corporation entertained the crowd with movies of the 1949 Notre Dame - Southern California game. His commentary on the film was not only entertaining but also carried a ring of authenticity for Paul knows the Irish brand of football better than most people. As a member of Notre Dame's football team in 1939, and 1940, and as captain of the 1941 team, he helped cook up plenty of bad medicine for the hapless opponents of America's number one team.

During the evening, results of the section elections were announced. Mr. Don Hoffman, of Evans-Winter-Hebb, was elected a national director, and also was made president of the Detroit Section. Mr. Paul Lillis, of Bakelite, became vice-president; Mr. Harry Haaxma, of Wolverine Plastics, became secretary; and Walter Kosy of Lyon, Incorporated was elected treasurer. The other five members of the Detroit Board of Directors are as follows:

Dr. Ernest Storfer, Chrysler Corporation; Mr. John Mickey, Ford Motor Company; Mr. Harry McGowan, Bakelite Corporation; Mr. Alvin Stomp, Una-Craft Eng. Company; Mr. William Biggers, Rohm & Haas Company.

## THORESON BUYS D. W.

The Thoreson-McCosh Co. have taken over the D. & W. Products, Inc., of Sandusky, Ohio, who developed the D. & W. Hopper Dryer for use on injection molding machines and thermoplastic extruders.

PAPERS PRESENTED AT
THE 1950 TECHNICAL CONFERENCE
of
THE SOCIETY of PLASTICS ENGINEERS, Inc.

# THE PLASTIC CALENDER AND ITS AUXILIARY EQUIPMENT

By THOMAS J. KERR
YARDLEY INDUSTRIES, INC., CHICAGO, ILLINOIS

The title of this paper is, perhaps, a misnomer. It would undoubtedly be more accurate to refer to the equipment as the rubber calender adapted to the formation of plastic film and sheeting. The purpose of the paper is to suggest ways in which this machinery might be further improved or redesigned to increase its utility.

Most calender operators have established as standard procedure the following sequence of operations: first, pre-blending of the ingredients; second, banbury mixing; third, milling; fourth, the actual calendering or forming of the sheet. There are many ramifications in the practice of the individual manufacturers. Some are the result of the adaptation of available equipment best to produce the desired product; others stem from extensive research and experience in determining how best to manufacture a specific item.

In many plants pigments, fillers, and stabilizers are pre-dispersed in plasticizer, using paint or colloidal mills. The resulting pastes are added to the resin plasticizer blend in the pre-blender, the banbury mixer, or on the mills.

Plasticizers are often preheated prior to blending to increase the rate at which they are adsorbed by the resin. Others use pre-blenders in the form of jacketed mixers which may be warmed by direct heat. Blenders which heat the stock by forcing hot air through the mixture during agitation are also used. All of these operations are designed to increase the adsorption of the plasticizer by the resin, and the intimate dispersion of the stabilizers, pigments, and fillers in the resin plasticizer system before banbury mixing or milling. As a generalization, it can be stated that the pre-blending operations have contributed definitely improved characteristics to the finished film or sheeting.

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Since the intimate and complete mixing of the ingredients is accomplished prior to the banbury mixing, the primary function of this mixer becomes that of a heat exchanger to convert the blended mixture into a plastic mass by raising the temperature of the stock. This immediately raises the question, "Is this massive machine the most practical and economical heat exchanger for this purpose?" A considerable proportion of the heating effect is the result of mechanical work in the mixer. This is definitely an inefficient method of heat transfer. It has been reported that extruders or machines employing this principle, such as the German mixer, have been used for turning the stock into a plastic mass, instead of the banbury, but again much of the heating is the result of mechanical work.

As the temperature of the mixture is raised toward the point where it becomes plastic, the stock starts to fuse and passes through a stage where it requires a maximum of power to keep it agitated, so that it may be heated uniformly without decomposition from overheating, if it is being handled in quantities which permit the formation of a large plastic mass. This characteristic makes it necessary to find some way to heat the material without allowing it to bulk, if we are to obtain a uniform product in the plastic state that will sheet properly without the use of equipment such as the banbury mixer.

As one approach to this problem, it is suggested that the pre-blended stock be uniformly spread in a layer on a stainless steel belt or other suitable conveyor, carried through an oven, raised to the proper temperature, and then fed directly to the calender.

Rubber stocks, in general, as processed on the calender retain considerable nerve. The processing is usually at temperatures low enough that the stocks retain a maximum viscosity. These conditions require a maximum of horsepower for processing. On the other hand, most plastic compounds are calendered in a molten or semi-molten state, in which condition they have a minimum viscosity. Accordingly, the power requirements for the plastic calender are much lower than for rubber. This suggests the possibility of designing entirely new equipment for plastics, using a number of smaller rolls to form the sheet, avoiding the heavy construction which is essential in the rubber calender.

Calender roll deflection is a major problem for the operator, particularly when he is required to produce films of different gauges on the same calender.

The viscosity and plasticity of the stock are varied by many operating conditions. For example, changes in formulation such as a variation of the type or amount of plasticizer may produce a major change in these characteristics at a given temperature. Changes in speed of the calender increase or decrease the amount

of friction heat produced, and this in turn changes the viscosity of the stock. Variables such as these, as well as the thickness of the film being produced, affect the force which tends to separate the rolls, and change the degree of roll deflection. This change is then reflected as a variation in gauge across the sheet. The use of heavy rolls has been necessary to minimize the deflection. The rolls have been crowned to compensate for the deflection which occurs. Even under these conditions it has not been found possible to obtain uniformity of gauge if it is necessary to produce sheets of different thickness on the same calender, for a degree of crown which would produce an even gauge in four mil film makes a sheet of twenty mil sheeting which is definitely thin in the middle.

Some of the calender manufacturers have recently made important improvements in adapting the rubber calender to produce plastic sheet of exceptionally close gauge tolerances. While this has been accomplished by many refinements, one of the major changes is in calender design to permit adjustment of the roll positions both vertically and horizontally. This allows the operator to adjust the rolls in such a manner that the axes of the rolls are crossed.

Crossing of the axes does not alter the position of the rolls in respect to each other at the center, but does bring the rolls apart at the ends, thus producing the same effect as crowned rolls. Even more important, the effective crown may be readily changed to compensate for the variables of operating conditions and the type of compound used.

It has been found that the effect on the gauge of the film by differentials of temperature and viscosity, as well as the variations resulting from uneven feeding, may be more easily controlled by the use of a four roll calender. Four rolls create three stock banks instead of two as in the conventional three roll rubber calender. This makes possible more accurate gauging of the bank between the rolls which form the final sheet and minimizes the effect of uneven feeding on the finished film. Obviously the incorpation of more rolls in the calender would permit further refinements in the control of the operation. Based on present design, the size of the machine which would result from the use of additional rolls, and the increased cost of the installation, have not encouraged the construction of such equipment.

If the temperature of the stock were raised to the point where it has a minimum viscosity before feeding to the calender, and the cross-axis principle used to compensate for roll deflection, it appears that it might be possible to design a precision machine using much smaller rolls and a much lighter frame, which would still produce a uniform sheet.

Such a calender would be lower in cost, easier to install, and cheaper to operate and maintain. It should give even better control of the manufacturing operation, for it would be simpler to regulate roll temperatures with smaller rolls.

As the use of plastic film and sheeting has increased and new uses developed, the problems involving auxiliary equipment to produce decorative effects have become major ones. Much can be done by the equipment manufacturers to better adapt the present embossing, printing, and coating machinery to the handling of unsupported film.

Competition has also created the necessity of producing film and sheeting having perfection in appearance as well as improved physical and chemical characteristics. This is a desirable condition from the point of view of the general welfare of the industry. But coupled with higher production speeds, it has created the necessity of improving the calender cooling and wind-up train for better handling of the film under these conditions.

It was readily apparent that the applications of plastic film and sheeting would be increased by the use of decorative effects. It was only natural to turn to the equipment used by textile and coated fabric industry for this purpose. However, textile and coated fabrics have one fundamental difference from plastic fllm, that of the dimensional stability under tension, which is imparted by the yarn. Even the finest of this ecuipment tends to stretch and distort film, particularly at elevated temperatures, which may be required to dry printing inks, top coatings, and spanishes. Many plastic manufacturers have adapted existing equipment for the purpose in their own plants by rebuilding to give it more precision. However, there is a definite requirement for embossing, printing, and coating equipment designed to give the film adequate support, handle it without tension, and wind it uniformly and smoothly at high speeds. Machines of this type have been built to the individual requirements of a few processors, but there should be a real market for a line of such equipment, correctly designed and carefully built for the industry.

In most of the early production of film and sheeting, the calenders were operated at speeds from seven to fifteen yards per minute. Now film is being produced at speeds up to one hundred yards per minute, and sheeting at speeds of twenty-five to forty yards per minute. Experience has taught that the less these products are handled after calendering, the better the condition of the finished goods upon delivery to the fabricator. Thus it has been found desirable to incorporate operations such as embossing, trimming and inspection in tandem with the calender, because it not only reduces the operating costs, but also improves the quality and appearance of the product. The roll as it is taken from the calender should be ready to pack and ship. Each time the film is re-wound, the probability of stretching, wrinkling, and uneven winding is increased.

It is not good practice to reduce the speed of the calender for roll changes because of the effect upon the gauge and quality which speed variation induces. If one is producing sheeting in sixty yard rolls, at forty yards per minute, a roll change comes every ninety seconds. Film in two hundred yard rolls at one hundred yards per minute necessitates roll changes every two minutes. Under these conditions, it is extremely difficult to cut the sheet and start a new roll smoothly in the time available. Various ramifications of the techniques used in the textile and paper industries for making rapid changes are being used. None have proven wholly satisfactory. The industry will benefit greatly from any changes in equipment which can be devised to improve this phase of the operation.

Several manufacturers had independently worked out the techniques of low pressure embossing for both coated fabrics and unsupported film, in tandem with the calendering operation, utilizing the fact that the plastic as it came from the calender could be readily molded by embossing rolls. With the sale of the equipment of the Zapon-Keratol plant, knowledge of this process became generally available. At the present time, at least one manufacturer of textile machinery is offering equipment of this type. Further development work is desirable, however, to improve the synchronization of embossing, cooling, trimming, and wind-up machinery, so that the film may be handled at high speeds without distortion or mechanical injury.

Much has been accomplished by the equipment manufacturer, in adapting existing equipment for the manufacture of film and sheeting. In the future, they can pace the advancement of the industry by devoting all possible research to the designing of specific machinery for the manufacturing and processing of these products, based on the experience of the plastic processors during the past ten years, and in line with the requirements which have developed as the fleld has expanded.

# FLUID HEATING and HIGH-TEMPERATURE COOLING FOR CALENDERS and PRESSES

By P. L. GEIRINGER

CHIEF ENGINEER, AMERICAN HYDROTHERM CORP.

The problem of heating plastics equipment has been approached from very different angles. Gas heating and electric heating have been used to some advantages for small plants and for certain processes. In general, however, the American plastics industry has hitherto used steam as the favorite heat carrier. Many serious difficulties have been encountered in the use of steam as heating medium and numerous methods were tried to improve steam heating systems. In Europe the same development took place. However, in about 1919, an engineer of the I. G. Farben Trust, who operated one of the first and largest plastics sheet factories in Troisdorf-Koeln, decided to try another heating medium in place of steam. As a result, he designed the first heating plant using high-temperature water under pressure as the heating medium for their numerous large platen presses. He installed the first large high-temperature fluid heating plant. Mr. Klingelhoefer, who designed this plant, took out the first patents and developed a system which is, however, at present completely superseded by a different design, which we are using. Nevertheless, the basic idea of high-temperature fluid as a heat carrier was utilized by him. He experienced the great advantages offered by this new heating method. More intuitively, more experimentally, and without any theoretical knowledge, he approached the difficult problem, and only at the present time, nearly thirty years later, after having obtained considerable experience with fluid heating and after the hard work of research by numerous scientists such as Jakob, McAdams, Nusselt, Erck, we slowly begin to understand theoretically, the great advantages offered by fluid heating compared to heating by the condensation of steam.

### A) THE DEMANDS OF THE PLASTICS ENGINEER:

1. Plastic processes require heating systems where, over surfaces of considerable extent, uniform temperatures have to be maintained. The temperatures used for the past ten years have been between 200-400°F, and at present for a number of plastics materials the demand has been increased to temperatures of 500-600°F. and in some cases even as high as 700°F.

PAUL L. GEIRINGER

2. Besides the high temperatures, the cooling of plastics materials is of equally great importance. The elimination of heat contained in the material, in the metal masses of the equipment, or the heat created by friction, as for instance in calenders, has become a rather important and difficult problem.

3. Finally, a very important demand is the design of a heating system which can be operated fully automatically in a pre-set cycle and independent of the skill of the operator.

These are the three basic demands of the plastics engineer, as far as heating and cooling is concerned.

### B) THE DEMANDS OF THE PLANT ENGINEER:

1. The plant engineer desires that the heating system operate without peak loads and without putting any sudden shocks on his boilers.

2. He further desires that the overall efficiency of heat transmission between the boiler plant and the heating equipment should be rather favorable.

3. That maintenance work is to be kept at a minimum.

Considering these demands of the plastics engineer and the plant engineer, it must be said that both groups are disappointed in the fulfillment of their requirements with the use of steam as a heat carrier.

In addition to those factors, the Hydrotherm System lends itself perfectly to gradual heating. This is of utmost importance with certain processes in which the material may be destroyed upon sudden heating and consequent rapid evaporation of water.

I venture to say that practically none of these requirements can be satisfied by steam heating, but that they can be fully satisfied by using fluid heating.

### THE LIQUID HEAT CARRIER:

For temperatures up to 450° F. we have found it practical to use water under pressure as the heat carrier; between 400-700° F. we use a heat transfer fluid which remains in the liquid state at the elevated temperature and at 760 mm pressure. The one fluid, which we call "Hydrotherm 500" is a chlorinated biphenyl which permits temperatures up to 550° F., and another fluid, which we call "Hydrothem 700", is an Aryl-Silicate, which permits temperatures reaching 650° F. and even higher. Dowtherm in the fluid phase may also be used.

### COMPARISON OF STEAM AND FLUID HEATING:

To simplify matters I have prepared a table showing the demands of the engineers operating plastics plants and how far they may be satisfied with steam and fluid heating.

You will see the first demand is the uniformity of surface temperatures. Most engineers believe that it is easier to heat a surface uniformly by means of steam than by means of a hot liquid passing through the equipment. They conclude as follows:

Steam condenses at a constant temperature, and therefor the equipment temperature should be uniform. In order to transmit heat by means of a liquid there must be a temperature difference between the incoming and outgoing liquid, therefore, the temperature of the surface **cannot** be uniform. This reasoning seems pretty obvious, but it is basically erroneous.

It is correct that steam condenses at a uniform temperature if kept at the same pressure, but this does not mean that the heat transfer **is uniform.** On the contrary, the heat transfer **is very un-uniform.** The investigations of Nusselt, of Erk 1928, of Eck 1929, all conducted in cooperation with Professor Jakob, and finally

## TABLE

### The Demands of the Plastics and Plant Engineers.

REQUIREMENTS OF A MODERN HEATING SYSTEM FOR ALL TYPES OF PLASTICS EQUIPMENT.

| | DEMAND OF THE PLASTICS ENGINEER | STEAM SYSTEM | HYDROTHERM LIQUID SYSTEM |
|---|---|---|---|
| 1 | UNIFORMITY OF EQUIPMENT SURFACE TEMPERATURE | ± 10° TO 15° F | ± 2° F OR BETTER |
| 2 | SIMPLE AND EFFICIENT COOLING SYSTEM | a NO TEMPERATURE CONTROL<br>b FLUID CHANGE REQD FOR COOLING<br>c SCALE FORMATION | a ACCURATE CONTROL<br>b SAME FLUID USED FOR COOLING<br>c NO SCALE FORMATION |
| 3 | AUTOMATIC OPERATION | UNOBTAINABLE IN STEAM-WATER SYSTEM | FULLY AUTOMATIC OPERATION ATTAINABLE |
| | DEMAND OF THE PLANT ENGINEER | | |
| 1 | NO PEAK LOADS ON THE BOILERS | NO SOLUTION FEASIBLE | FLUID ACCUMULATOR SOLVES THE PROBLEM |
| 2 | MAXIMUM OVERALL HEAT TRANSMISSION EFFICIENCY | CONDENSATE LOSSES, FLASH-OUT LOSSES ETC LOSSES 25% TO 40% | UNUSED HEAT RETURNED TO BOILER LOSSES DEPEND ON TYPE OF SYSTEM |
| 3 | MINIMUM MAINTENANCE WORK | REDUCING VALVES, CONDENSATE VALVES, SCALE REMOVAL CONDENSATE PIPE REPLACEMENT | CIRCULATION PUMPS REQUIRE NEGLIGIBLE MAINTENANCE PIPES HAVE INFINITE LIFE TIME |

the work of Max Jacob in 1936, have shed some light on this problem. I especially refer to the book of Professor Jakob, which has appeared only a few months ago. I bring you now one picture of this book (below) in which Professor Jakob measured the heat-flow of condesing vapors in a horizontal tube. He states, "By rotating the tube around the axis, the temperature at different angles against the horizontal axis could be determined. In these tests the temperature at the bottom was found to be much smaller than at the top, because of the increase of the film thickness from top to bottom. The flow of condensate in axial direction caused an increase of this difference in the flow direction." This picture shows the enormous difference of the film thickness at the bottom and the top. The thickness of the film on the top was only one-fifth of the thickness on the bottom. The lower curves represent the velocity of the film and also shows the film thickness. These film thicknesses were calculated and also measured by actual tests and found to be accurate. I do not want to bother you with formulae and mathematics, but I can assure you that by measuring surface temperatures on platen presses, the same resultant temperature gradient has been asserted and confirmed. I will now show you one picture of measurements of steam heated platens.

**Vapor Condensation in Horizontal Tube.**

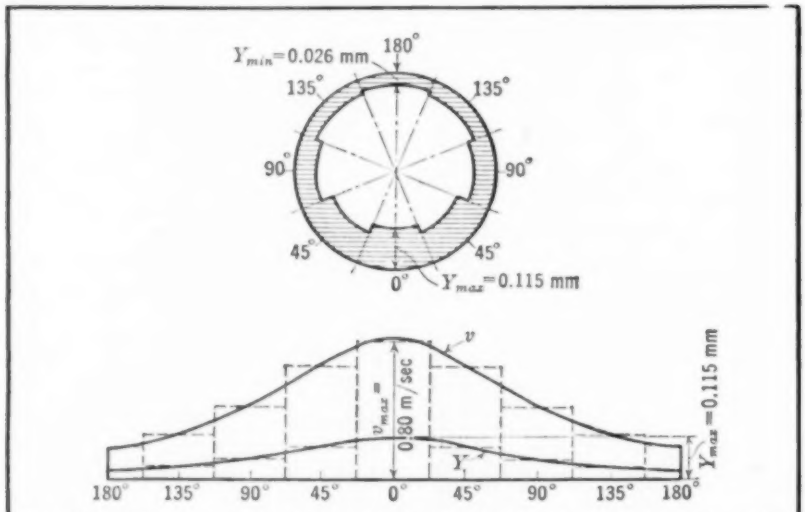



FIG. 30–5. Thickness and velocity of water film inside a horizontal tube in which flowing saturated steam is condensed.

PHOTOGRAPH OF PAGE 683 OF MAX JACOB'S BOOK "HEAT TRANSFER" ED. 1949
SCALE OF THICKNESS OF WATERFILM 30 TIMES OF THAT OF TUBE DIAMETER

You will see that the temperature differences on the surface of the platen is 15° F. and more. Most of you who have had practical experience with plastics equipment will know that even larger temperature differences on platen presses have been observed and that the top surface of a platen is considerably hotter than its bottom surface. Platen presses operated by fluid heating can operate with considerably smaller temperature differences and may have the surface uniformity of plus or minus 2° F. The heat transfer coefficient of fluids is uniform all around the bore of the platen.

You will see that a considerably smaller temperature difference on the surface has been registered. I am sorry that these measurements have not been extended to the bottom of the plate. The same experience, in reference to surface uniformity, was made on plastics calenders with drilled rolls. We have calenders in operation where we guaranteed a surface uniformity of plus or minus 1° F. You may ask how such a uniformity can be measured. The company which ordered the plant was highly interested in obtaining very close temperature control and we were in a position to prove by an electric registering differential temperature gage, which measured temperatures of 1/100° F., that the surface temperature did not vary more than 7/10° F. to 1° F. Such au niformity is completely unobtainable with steam.

The second equally important demand of the plastics engineer is the design of a simple and efficient cooling system. For many processes, as for instance thermo-setting and press processes, quick uncontrolled cooling with fluid of any temperature — provided the temperature is low enough — is acceptable.

However, there are other cooling processes, as for instance those used in the production of plastic sheets, where heat has to be eliminated at a certain rate, and still a uniform high-temperature has to be maintained. For these cases a careful controlled cooling is necessary. It is not possible to use direct cold water but it is required that the flow and the temperature of the water be carefully controlled.

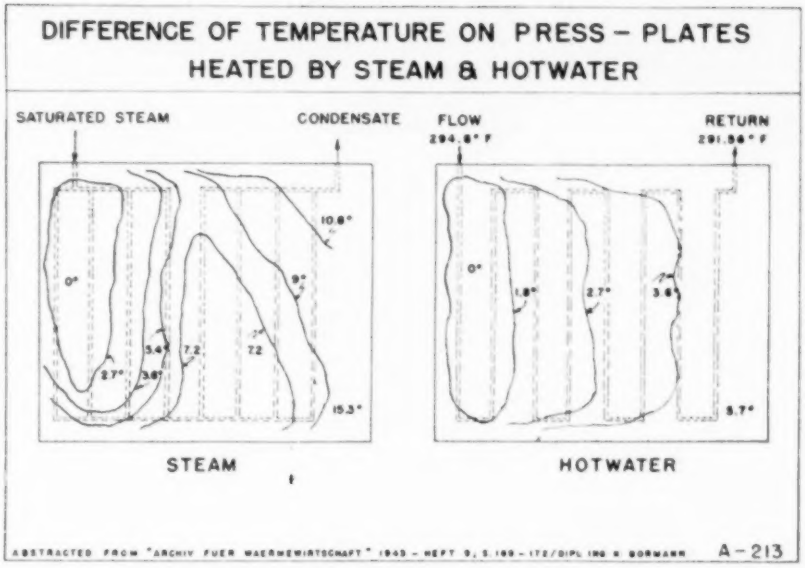
We show in this picture how we have solved this problem for the heating and cooling of calenders. You will see that we have two circuits arranged, one fluid circuit passing through a heat source, which may be a heat exchanger or a boiler, and one circuit passing through the cooler. Both circuits carry water of different temperatures. These two water streams are made available in front of each roll and are mixed in accordance with the heat demand of the roll. If heat has to be absorbed, water at a temperature below the temperature of the roll is admitted; if heating-up is required, the temperature of the water is above the roll temperature. Sometimes more circuits are needed, and this picture shows you a rather simple layout. We have installations in operation abroad and in this country which are fully automatic. They maintain the temperature of the roll in close tolerances of only 1° F., and it is possible to set the different temperatures of the rolls as close as 3° F., or as far apart as 30° F. to 50° F.

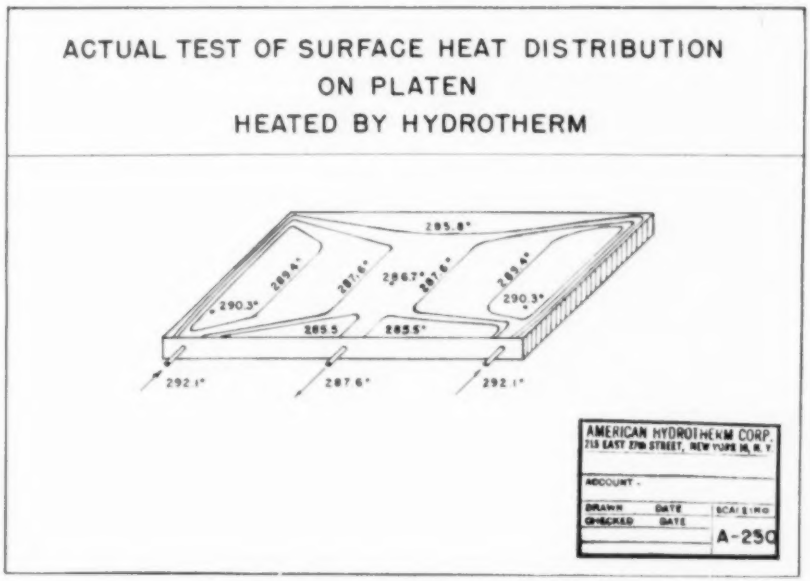
The automatic maintenance of cooling temperatures and the automatic switching from the cooling phase to the heating phase is only possible if one heat carrier is applied. No automatic control can be devised if steam is used for heating and water for cooling. We show you in the next picture a layout for a platen press where the whole process of heating and cooling is automatically controlled from one instrument which switches over the circuit from the heating to the cooling phase. In this way it is possible to have an absolute uniform product independent of the ability of the operator.

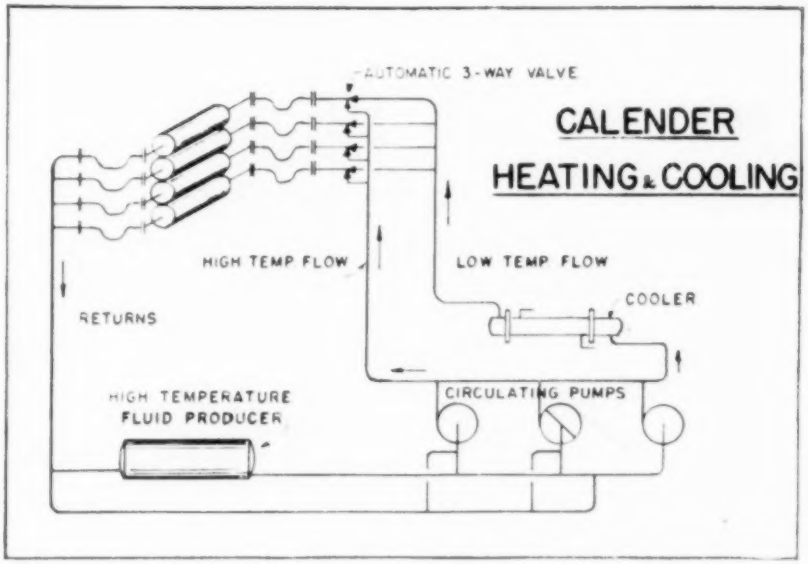
Last, but not least, we should not forget that the cooling with fresh water in an open circuit causes considerable scale in the equipment and often results in taking the equipment out of service. You probably have had these experiences.

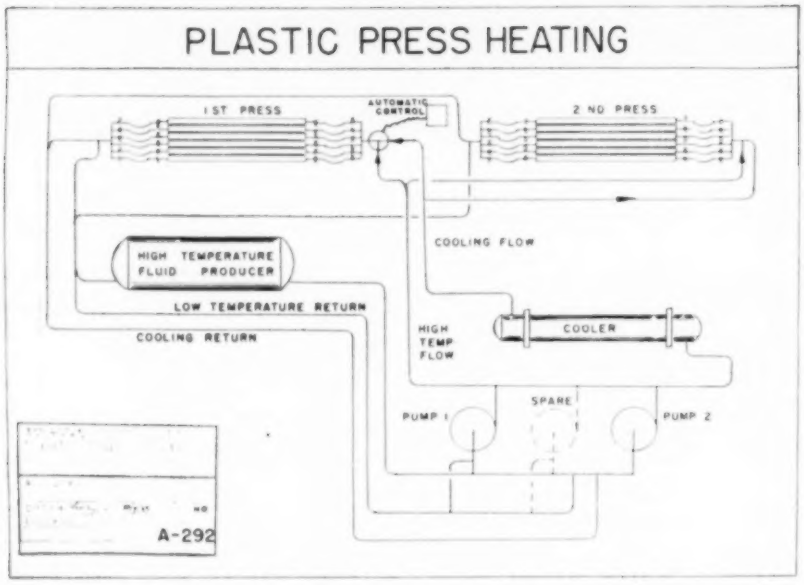
Finally we want to deal with the demands of the plant engineer. Shock loads caused by the sudden heating up of platen presses and calenders are rather disturbing. With steam they cannot be eliminated; the design of steam accumulators would require higher boiler pressures and entail fantastic costs. If high-temperature fluid heating is used, the accumulation problem becomes rather simple. Accumulators operating at a uniform pressure are utilized and they reduce to a minimum the peak load created, for instance, by the sudden heating up of presses.

The efficiency of steam heating for plastics equipment is rather low. If one considers, for example, that the condensate leaves the plastics equipment at a temperature close to that of the steam at 350° F., the con-






densate losses and the flash-out losses are rather high. There is much equipment on the market which endeavors to reduce these losses. How excellent this equipment must be if it is to compete with a fluid heating system which has practically no losses and where all the unused heat is returned to the boiler.

The peak of efficiency can be obtained in installations providing solely heating. In installations where heating and cooling have to be considered, some losses have to be accepted because some of the water contained in the circuit is subjected to the cooling process together with the equipment. These losses, however, are insignificant compared to the other advantages gained.

Finally a few words about maintenance should be said. Steam heating requires the maintenance of numerous reducing and condensate valves and traps. Fluid heating needs only the supervision of some pumps. Experience shows that this maintenance is rather negligible.

Before closing we want also to mention that the power costs for operation of the fluid heating system are comparatively low. It is difficult to give any figures on the power costs, but certainly these costs can be kept at a figure where they may be disregarded in the operation costs.

I would further like to call your attention to the fact that about twenty-five of the largest plastics corporations in Europe have installed fluid heating, and we feel sure that fluid heating offers the plastics industries such great advantages that it will be used more and more to the benefit of this industry.

# ELECTROSOL - A DEVELOPMENT IN ELIMINATING ELECTROSTATIC ACCUMULATIONS IN PLASTICS

By MERRILL J. AINSWORTH
ENGINEERING CONSULTANT

Fundamentally, the words "static electricity" mean electricity which is standing still, being derived from the Greek "statikos" meaning to stand. As we think of the term today, we use it primarily to distinguish the conditions and effects which are observed between electrically charged bodies and the very different quantitative effects of power, light, and heat generated in employing electricity of the "dynamic" or moving variety.

The purely static effects of non-moving electricity may or may not be of industrial importance. Where they produce results or prevent production of results related to the dollar they unquestionably are. Further, in industrial practice the formation of such static charges is usually a continuous process. As the operation continues, electrical potentials rise to a point where the attraction or repulsion of the charges involved exceeds the dielectric strength or insulating capacity of the surrounding air or material. At this point the "static" electricity becomes "dynamic" and is discharged in the form of a spark and associated electrical current.

MERRILL J. AINSWORTH

We are all well acquainted with the discomfort and annoyance of electrical discharge when it occurs from the finger tips or other parts of the person. Such accumulations are usually occasioned by walking across a rug, sliding across a car seat or other friction producing circumstances. Then contact with some grounded object produces the discharge and accompanying nervous jolt. Generally the shock experienced is harmless and is annoying only because it is unexpected. However, when such sparks occur under inflammable or explosive circumstances the jolt is frequently more than a nervous one.

The escape of static electricity from a charged conductor does not always occur as a single, defined spark. On the contrary it may occur intermittently and in continuing succession giving rise to a condition known as corona, or historically as St. Elmo's fire. Such discharges consist of a rapid succession of tiny sparks extending from the charged body, each spark of which dissipates a portion of the charge on the body into the surrounding air. This condition is frequently observed by airline passengers in the form of discharge from the static discharge devices and extremities of the airplane in which they are riding — frequently to their dismay and consternation.

Such discharge, being rich in energy in the radio frequency portion of the spectrum, frequently plays havoc with radio and communications. Such terrific charges build up on aircraft flying through rain and snow that in one case a spark four feet long was known to have passed between the pontoons of a seaplane and the water upon which it was landing.

Static electricity was first discovered by Thales of Miletus in 600 B.C. Fortunately, it did not cause serious trouble in industry for some time thereafter. While current electricity was not observed until 1780, it is interesting to note how much we have learned about it since that time, compared to how little we have learned about the static variety in over twenty two hundred years since its discovery.

Until recently there had been little knowledge of the exact nature of this fundamental phenomena. Further, there had been little effort directed at the problem, and little pure or applied research expended toward its solution.

Static electricity has for years created serious difficulties in the plastics, textile, and paper industries. It engenders many problems of the annoyance class in a wide range of fields and activities. Any place where non-metallic materials must be handled in quantity or with speed and where electrical non-conductors are used is fair game for static electricity.

The range of electrical voltages experienced from this cause is something of interest and is seldom appreciated. Voltage measurements taken by the spark gap method have been found to range from 5,000 to 100,000 volts! In paper processing and printing machinery these charges have become of such magnitude as to set the paper being processed on fire. Needless to say, equipment and material bearing such electrostatic potentials is neither comfortable nor safe to work about. On conveyor systems and drive belts, voltages of the order of fifty thousand volts have been measured with regularity. Such conditions present problems consistently in manufacture of textiles, ginning of cotton, mixing of pigments and paints, and in the manufacture of oilcloth and rubber goods. Rubber spreading machinery, spot-proofing machinery, naphtha cleaning machines, and fluid and gas transport equipment all present peculiar problems with respect to static electricity.

Static electricity is produced in practically every case where two bodies are suddenly separated or in which a piece of material is broken. One body is found charged with electricity of one sign and the other with that of the opposite. This is because the electrons and protons are so intermingled that an excess invariably adheres to one side or the other at the plane of separation.

Static electricity is frequently referred to as frictional electricity because such charges are produced by the rubbing of one body upon another. It seems highly probable, however, that in all such cases the friction between the two bodies is merely incidental and that in the process of rubbing, the materials are first brought into intimate contact and are then separated.

A wide variation is noted in the susceptibility of different persons to becoming statically electrified, either by friction or induction. Cases are observed where employes have been terminated or reassigned where they were involved in plastics operations because they were abnormally liable to become electrified, thereby unduly complicating the operations at hand. Experience indicates that the sole difference between these "human dynamos" and their fellows lies in their lesser tendency to perspire, so that their clothing, and particularly their shoes, is drier and hence, a better insulator. Shoes having conductive rubber soles are often of value in such situations.

Plastic articles and materials can be effectively charged by mere proximity to charged matter or persons. To illustrate, suppose a negatively charged tank truck drives up to a filling station. A person standing nearby who does not touch the truck but who happens to be touching a grounded object will have a positive charge attracted to him from the ground if he is in contact with it. Then, assuming that he is wearing rubber insulating shoes, if he interrupts his contact with the ground his potential will immediately rise. If he later brings his hand near ground a discharge will of necessity occur.

Such induced charges are frequent causes of fires where a metal roof structure has insulating wood framing. A heavily charged thunder cloud will float overhead and an opposite charge gradually leaks through the wooden building members to the metal roof. When the cloud is suddenly discharged by a lightning stroke, the roof discharges with equal suddenness to the ground. Sparks and fires result.

Humidity is a factor of great importance in electrostatic phenomena. Plastic parts and devices should always be designed and tested for the worst, meaning the dryest, humidity conditions they will encounter. The surface resistance of a plastic, and with it the static problem, may be a million times more acute at a relative humidty of 30% than it is at a relative humidity of 80%. Contrary to popular belief the presence of water vapor in the air does not tend to make the air electrically conductive. Actually its conductivity is decreased by such addition. The change in the electrostatic problem on plastics with variations in humidities is due solely to formation of an infinitesimal film of water on the surface of the part or material.

Artificial humidification to 70% relative humidity produced by blowing steam into the workroom, wet cloths hung up and floors kept perpetually damp are tricks employed in some cases to combat static. However, such systems are not compatible with use of molding powders, are unhealthy and damaging to employe morale, and are extremely injurious to equipment and facilities. Results, of course, are only effective while the work, parts, or material is in the humidified area.

If two bodies are charged differently, one being positive and the other negative, the attraction of the opposite charges will produce a force and the system can do mechanical work by overcoming an opposing force if one body is allowed to approach the other. This electrostatic force increases with an increase in either charge and with a decrease in the distance between them. If a small quantity of the positive electricity is allowed to move across to the negative body, it performs work, useful or otherwise, by its motion. The amount of work, per unit charge, serves as a convenient measure of the electric forces which are present and is called the potential difference, or voltage between the two bodies. In the simple truth of these statements lies one of the greatest and costliest annoyances in the plastics industry — the results of static electricity.

It is in the plastics industry where where this manufacturing demon most frequently rears its ugly head. Problems involving static electricity and plastics generally may be considered in four categories:

1. Problems of handling and fabricating materials. Static electricity adds immeasurably to difficulties of many operations in the formulating, processing, and fabricating of these materails. Time is lost and costs mount when materials are stubborn to handle; sheet stock sticks together or wanders crazily in search of oppositely charged material. Work flow is hindered by adhesion of material in process to other material or foreign matter. Material and equipment are uncomfortable to work with and production suffers. Quality is hampered by improper forming, molding, or processing attributable to this cause.
2. Problems affecting mechanical performance of the plastic ar-

ticle being manufactured. This difficulty occurs where plastic housings are used for mechanical or electrical equipment, or as moving parts of mechanical assemblies. It may, for example, cause erroneous performance or prevent operation of a low torque meter movement where such a movement is housed in a plastic case or covered by a plastic lens. Light weight plastic mechanical assemblies relying on low mechanical or electrical forces for operation may be effectively s t o p p e d by an electrostatic charge.

3. Problems of appearance of the material or manufactured article. All pieces or particles of material of all kinds are always at some electrical potential. Wherever a difference exists in the potential of two pieces, they are attracted to each other with a force similar to that of a magnet and a tack. Thus, when a plastic article or plastic material acquires a static charge, it is at a substantially different potential than all of the dust, dirt, lint, and particles of foreign matter in the air and in the immediate vicinity. The part or material hence attracts such particles to it, becomes unsightly and loses its attractive appearance. Attempts to wipe the surface clear usually result in increasing the static charge, adding lint from the wiping cloth, and generally unsatisfactory results. Continued wipings, as of a display case or rack, only serve to destroy the natural luster and beauty of the original plastic.

4. The problem of hazard to material, facilities, and personnel. Plastic fabrication technique customarily employ solvents, thinners, cements, and paints which are volatile or inflammable in nature. A voltage of 50,000 volts will produce a spark about three quarters of an inch in length, ample to create a serious fire and explosion hazard, even under normal conditions.

As with any problem of research, to provide a positive and properly engineered solution, the fundamental underlying segments of the problem must be discovered, established, identified, and analyzed. Only with a true and complete understanding of the fundamental phenomena involved can a proper approach be made to a solution.

A worth while industrial solution to the electrostatic problem must take into account the phenomenon of ionization. Some types of energy radiation, including that from radium, x-rays, and ultraviolet, as well as some chemical reactions have the property of in effect jarring loose electrons from their associated molecules. Such loose electrons may then move freely among the other molecules, they may become attached to previously neutral molecules, or they may find molecules which lack an electron and recombine with it to form a neutral molecule.

Electricity, for purposes of our discussion, may be thought of as an extremely penetrating and fluid substance provided by Mother Nature in two standard packages. The variety we call negative is extremely small and light and we term its units "electrons", whereas the positive variety which is about two thousand times as heavy we call "protons". An atom is an aggregation of these electrons and protons together with particles which are electrically neutral and are fittingly termed "neutrons".

Fundamental forces impel electrons and protons to repel themselves and to attract each other, thus establishing a norm or equilibrium condition. When an excess of either occurs in a piece of matter, a thin plastic sheet for example, the resultant mechanical forces affect the whole sheet and it seeks a means of eliminating that excess.

In seeking to prevent the formation of static electricity it is necessary to consider what happens within a material when it becomes statically charged. All mater is composed of molecules which are in turn comprised of atoms of the fundamental elements.

The atomic structure of matter varies in arrangement of its protons, neutrons, and electrons in many ways. Each molecule constituting a piece of matter possesses a resultant electrical charge, some portions being positive and others negative in polarity. In uncharged matter, a piece of plastic for example, these molecules are arranged in purely random fashion. Hence, their individual electrical charges have no additive effect and an electrical balance occurs. The effect of a positive charge on one molecule may be cancelled by the positive charge of its neighbor. However, when the charges on the molecules are oriented in one direction, as is done by mechanical friction or by contact with a charged source, these charges all add together as in a series hook-up arrangement in a battery. The result is that with each molecule contributing its share, the total electrical charge over an area of the material can be tremendous.

In plastic materials we find the ideal combination of the factors necessary for accumulation of such a static charge. The materials are fundamentally electrical insulators, in fact are among the best insulators known. Electrical loss factors are low. The very things which account for their demand in electrical applications are those which cause the trouble with static electricity.

Understanding what happens within a material we can now appreciate that a static charge can occur over a small localized area of a plastic body. Likewise, many charges of different polarities and magnitudes may occur over different areas of the same body — in fact over any area larger than a molecule of the material itself. We can also understand why conventional antistatic waxes, solutions, and mechanical methods are unable to prevent orientation of the molecular lattice structure of a plastic material in this fashion.

The mechanical friction or surface separation necessary to establish an electrostatic charge is very slight. Normal removal of a molded article from the steel mold cavity is ample. Handling in removal of material or parts from shipping cases or production stowage racks is adequate. Transfer f r o m ones body when charged to plastic material occurs rapidly and instantaneously. A power driven conveyor belt will readily create a high charge and transfer it to plastic parts or assemblies it carries. A worker charges a part of material merely by contact if he has a charge on his person.

To be completely effective in elimination or control of static electricity in plastics, the means employed must:

1. Prevent the accuculation of an electrostatic charge on the parts or material involved.
2. Be permanent in its effect. Treatments lasting from a few minutes to a few days are of little value in articles manufactured for later sale.
3. Be impervious to varying conditions of temperatures and humidity.
4. Be unaffected by normal handling and other processing which may be required.
5. Be of such a nature that it does not damage appearance of the article or material processed. It should have or incur no undesirable appearance factor itself.
6. Be so composed as to be inert in its effect on normal paints, lacquers, and enamels since it is often desirable to use these materials in conjunction with plastics.
7. Be of such a nature as to remain inert in effect on all of the common plastic materials. It should engender no chemical, electrical, or mechanical detrimental action on the material, either in processing or thereafter.
8. Be of such low cost as to permit its ready use in applications involving large quantities of materials and low cost production.

9. Be a process or treatment that does not add hazards or difficulties of its own.

These are truly stringent requirements and appear to be demanding of the ultimate in an antistatic process.

However, such a process is available! It has emerged from the laboratory, been subjected to exhaustive tests and evaluation, and is finding ready application in the plastics industry. It is commercially identified as the Electrosol process.

Let us see how this process accomplishes its function. From an understanding of what happens in a plastic when it becomes charged, it is apparent that to be effective the process must prevent orientation of the molecular lattice structure of the material. This is done by the Electrosol process in a unique and unusual manner using an entirely new and different approach. The process, as applied to a typical problem in the plastics fabrication field, consists of a two stage dip or spray application of two successive formulations. The first material (Electrosol No. 1) is a burgundy colored translucent fluid consisting essentially of four classes of material:

1. An electrical insulator of uniform characteristics to insulate the processed material or part from the material to follow (Electrosol No. 2).
2. A dispersing and wetting agent for this and the second material.
3. A catalyst for the complete process reaction.
4. A vehicle to provide uniform deposit, control viscosity and permit uniform pull-out in dip usage.

After a dip or spray application of this material to the plastic being processed and a twelve minute air dry at normal room temperature, the plastic is given an application of Electrosol No. 2. Fourteen minutes later at room temperature and the process is complete. Electrosol No. 2 is a low viscosity fluid with a slightly bluish cast. The result of the second application is an unchanged original material, the surface of which can not be electrostatically oriented and which prevents orientation of the parent material it covers. Hence, no static charge can exist.

The total Electrosol deposit on the parts or material processed averages 0.00035 inches in thickness as measured on the Do-All Electronic Comparator and the Pratt and Whitney Super Micrometer.

This explains the low cost of the process as material pullout on dip application is so low.

Original appearance of the processed part or material is unhampered. Surface finish is unaffected and transparency is good. No discoloration of the material occurs and all color in the processing materials themselves is dissipated in the process reaction.

There is no chemical reaction between the process materials employed which is detrimental to any of the acrylates, methacrylates, cellulose acetates and nitrates, phenols, styrenes, vinyls, and resins in common use.

Normal temperatures and humidities have no detrimental effect either on the results of the process or on the material processed. Surface hardness, abrasion, and scratch characteristics of plastic materials given the Electrosol process are frequently improved.

The entire process, including all materials used, has no ill effects on any of the paints, enamels, or lacquers commonly used in connection with plastics.

Electrosol materials are non-volatile, non-explosive, and non-inflammable. Other than a slight toxic effect of Electrosol No. 2 on the skin through prolonged direct contact, the industrial hazard is non-existent. Process operators normally wear rubber or neoprene gloves when handling Electrosol materials.

A typical production application of the process involved a piece of electrical equipment so designed that a cylinder of 0.010 thick cellulose acetate sheet was required to revolve from low torque within a second cylinder of the same material. Static accumulation was such that the device was rendered inoperative merely by handling in removal from shipping containers. Casual bodily contact with the device by the operator would also charge one of the cylinders and cause retardation and stoppage. Rapid movement of air past the stationary outer cylinder would create the same result. Many conventional materials, techniques, and methods had been investigated without success. Either the static elimination effect was not permanent, the appearance was detrimentally affected, or normal handling and cleaning would destroy the treatment given the device.

The Electrosol process accomplishes the desired results in this application and at a cost which is but a small fraction of the cost of systems previously used. Processing is accomplished in this case by conventional dip techniques. The cylinders are placed in inexpensive wire racks by the operator upon completion of the preceding cementing operation. Full racks are quickly dipped in the first tank containing Electrosol No. 1 and immediately removed. Drippings return to the dip tank. Twelve minutes later the same racks are dipped in the second tank containing Electrosol No. 2 and removed. Fourteen minutes thereafter the process is complete. The acetate cylinders are removed from the racks by the operator who performs the following manufacturing operation upon them. The sequence of manufacturing operations which follow on these cylinders leaves them unimpaired in appearance either by processing or handling. They are permanently static free.

The dip tanks employed in this application are inexpensive enamel coated steel. Since Electrosol materials are inert to enamels, more elaborate or costly tanks are not required. Tanks are set into the top of the processing bench flush with its surface to provide a convenient working height for the operator. They are kept covered when not in use to prevent needless introduction of foreign matter. Tanks are of twenty gallon capacity for a processing rate of 1500 cylinders (750 complete units) per day. By keeping the tank size and the material in the tanks no greater than necessary, it is possible for material pull-out and replacement to occur at a rate which eliminates excessive accumulation of dirt and foreign material in the tanks. Frequent cleaning of tanks or filtration of processing materials is thus avoided. Total processing costs, including amortization of all licensing and equipment costs over 50,000 units, is slightly under one and one-third cents per unit.

Another interesting application of the process involved a vinyl tubular sheath for an electrical cable connecting two places of electronic equipment. This sheath is cylindrical in cross section with a diameter of three-quarters of an inch and 0.015" wall thickness. The sheath was accumulating and supporting an electrostatic charge which was proving detrimental to the transient and signal voltages being transmitted by the cable. Corrective means other than one which was positive and permanent were valueless since the function was one of instrumentation of extreme importance. Electrosol processing of the vinyl tubing proved completely effective and was accomplished at a cost of approximately three-tenths of a cent per foot.

Phonograph records processed with Electrosol after pressing, no longer accumulated dust and lint as the result of a static charge generated by needle friction. This not only retains improved appearance but substantially reduces record wear and increases usable life by reducing abrasion from these sources. The record surface tends to be self-lubricating and surface noise is reduced. Work was done on this application by both automatic spray and dip techniques with results favoring the dip process. An installation similar to that described earlier for treat-

ment of acetate cylinders was employed. A slight modification of the Electrosol No. 1 material was performed to permit thorough dispersion within the record grooves without affecting dimension and resultant tonal fidelity. Cost of the process in this application is $0.00372, $0.00743, and $0.01068 per unit for the seven, ten, and twelve inch discs respectively.

Other interesting applications have suggested themselves for investigation and use. A raincoat of the vinyl film variety lost its objectionable tendency to stick and cling to the person and clothing of the wearer when the coat material was Electrosol processed. Transparent plastic molds of operating machinery, selling aids, and plastic inspection ports in regular machinery are obscured by lint and foreign materials due to the static charge generated by the rotating equipment within. Such difficulties are readily cured with Electrosol.

Plastic jewelry, luggage, automotive instrument panels, television masks, filters, and cabinets, retain their beauty, clarity, and luster longer when Electrosol processed.

Problems in both fabrication and appearance in the field of packaging merchandise in plastics are solved simultaneously by processing of the raw material.

With plastic grilles, louvers, radiator fronts, and ducting, where air passes regularly or rapidly, a static charge results. Where the resultant accumulation of dust and dirt is objectionable, or where static discharge sparks may prove hazardous, the condition can readily be relieved by Electrosol processing.

As a process for plastic sheeting, natural, synthetic and coated fabrics Electrosol will eliminate annoyances of static discharge when these materials are used for applications such as automobile seat covers. The process in such applications has also exhibited benefit as a shrinkage control treatment.

Processing of rubber and fabric hose such as is used in handling gasoline and volatile fuels has shown promise in relief of the hazard associated with spark discharge from nozzles of such equipment.

Treatment of plastic wall tiles in manufacturing preserves their beauty with a minimum of cleaning.

Molded windows and bubbles for automotive and aircraft use experience substantial accumulations of static electricity due to the rush of air past them. Resultant attraction of foreign matter requiring excessive cleaning entails loss of clarity. Static build-up and electrical discharge from such areas can disturb operation or radios, communications and other electronic equipment. Electrosol processing of the parts after molding or forming effectively relieves this condition.

No discussion of static electricity would be complete without a word in connection with a little known phenomena which takes its yearly toll in the plastics industry and elsewhere.

In work with plastics where volumes of inflammable solvents are used such solvents frequently become undesirably contaminated or dirty. The seemingly logical, and frequently disastrous, thing to do is to filter such materials through filters, chamois, paper, ceramic, or other porous material. When such action is performed, a very marked separation occurs not only of the dirt from the solvent, but of the positive from the negative charges within the solvent. A spark originates and another unexplained fire or explosion results.

A review of your solvent handling operations with this in mind, particularly those not performed completely in closed systems with all oxygen excluded, is certainly time well spent.

## DATA ON PHYSICAL CONSTANTS — ELECTROSOL PROCESS MATERIALS

Electrosol No. 1 and Electrosol No. 2 are both provided in liquid form for dip and spray processing. Specific gravity of the No. 1 material is 0.97. Specific gravity of Electrosol No. 2 is 0.95. Viscosity of the two materials is maintained at 1.03 cps and 1.51 cps respectively at 70 degrees Fahrenheit (21.1 C°) to control material pull-out on dip applications. Neither material is flammable.

Weight per gallon of Electrosol No. 1 is 8.08 pounds, and of No. 2 is 7.92 pounds. The pH of No. 1 is 6.8 and of Electrosol No. 2 is 7.6. Both materials are non-compatible with most common organic solvents.

Electrosol No. 2 is slightly toxic to human skin. Prolonged or continuous exposure is to be avoided. Operators customarily wear rubber or neoprene gloves.

In processing, air drying at room temperatures is satisfactory and is commonly used. However, infra-red or oven equipments maintaining temperatures anywhere below the heat distortion point of the materials being processed may be used to speed drying.

The bond formed with the parent material is a surface impregnation. Its performance and characteristics with regard to migration, leaching, and disassociation is largely a function of the molecular pore structure of the material processed. With most material and in most applications the degree of permanence is such as to provide useful and usable results.

Attraction for dust and lint, and other undesirable characteristics of an electrostatic charge is eliminated entirely or substantially reduced on all materials with which the process is usable. Light transmission in transparent materials is reduced by a factor of about 0.4 of one percent by Electrosol processing. Mar resistance, resistance to solvents, and moisture absorption are generally unaffected although with some materials slight improvements in the latter two factors have been noted. Abrasion resistance with the softer materials appears slightly improved by processing.

Our experience indicates that processing of the conventional styrenes and laminates has little effect on their dielectric properties. The dielectric constant, and also the power factor at frequencies up to 100 megacycles, remains relatively unchanged. Our work at higher frequencies is at this time so sketchy as not to provide competent data. Observations are that the dielectric strength (volts per mil) suffers slightly on some materials and is improved on others as the result of processing.

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# SOME SUGGESTED IMPROVEMENTS FOR INJECTION MOLDING MACHINES

By ELMER E. MILLS
ELMER E. MILLS CORP., CHICAGO

The writer hopes that some of the suggestions in this paper may be used to produce machinery which is better adapted to the plastics industry than equipment presently available. The suggestions are the fruit of practical experience, and no criticism of any machinery manufacturer is intended.

The machines do not do the entire job and a certain amount of skill in their operation is necessary. Many of the features that are a part of each individual manufacturer's machine and not common to the others are good in themselves, but most of them are of rather trivial value. Basically we should like to have a machine that is safe, economical, flexible, simple to maintain and inexpensive to operate.

Under safety I should like to have a machine so designed that the operator is safe at all times. The safety gate should open with the press unless set to do otherwise. In this manner when an operator removes a part from the press the gate is opened automatically, thereby preventing the closing of the machine on a casting and damaging the mold. There are a few rare instances where a job can be run completely automatic and provisions should be made for disengaging this feature on the gate for that particular type of operation.

Inasmuch as there is constant pressure on price, it is important that the machines be economical to operate and maintain.

Under economy of operation, the machine should be faster opening and closing of the die plate and should have much longer stroke of the die plate available than on any machine on the market today. This long stroke should be adjustable so that it can be shortened when desired and should be extremely fast with controllable deceleration at the end of the stroke both as to rate of deceleration and distance under which this deceleration takes place. It is conceivable that a die plate could open faster until the knockout bars become engaged and then slowly push the part out and avoid the shock of a fast blow on the knockout, which in some cases may result in fracturing or damaging the part. This should be adjustable because some parts would require a short travel of the knockouts before they would be completely released while others would require a long travel so therefore the length and rate of deceleration should be under complete control of the set-up man. The same thing holds true on the closing of the press. If the stroke were long and not adjustable, the time lost on those jobs would be uneconomical, so therefore by shortening the stroke for those jobs which do not require a long one would result in a time saving, which would be valuable.

ELMER E. MILLS

The reason for the long stroke is the saving in mold cost for those deep draw jobs which require external core tooling equipment because of the fact that the press does not open far enough to produce the product in the normal manner. We have spent many thousands of dollars in the construction of such molds simply because the press does not have long enough movement of the die plate.

Any steps that could be taken to reduce the cleanout time and the amount of material wasted in purging a heating cylinder would be quite desirable. While it is possible to clean some materials out of a heating cylinder by purging with another, we find many times that it is necessary to completely dismantle the heating cylinder and in that way lose operating machine time.

Some time ago one machine manufacturer suggested the possibility of a turret arrangement with several heating cylinders being adjustable into position so that this cleaning time could be reduced by a quick shift from one cylinder containing one material to another containing a second material. If something of that sort could be developed, it might prove helpful if it does not increase the cost of the machine too greatly.

There is much room for improvement in the heating cylinders although they do plasticize the material. They do so at the expense of a tremendous amount of power and something should be done to reduce the brute strength that is required to mold a plastic part. The unplasticized material in the cool end of the heating cylinder requires the expenditure of tremendous power to force it into the plasticizing chamber where it becomes melted. This results in straining everything in the machine as well as the mold. Some development has recently been done along this line and we know of one manufacturer who has a pre-plasticizing arrangement on his equipment, but as yet this equipment is untried and there are questions about the practicability of its operation which only time can prove. Another manufacturer has a pre-plasticizing chamber in his machine, but the same thing holds true there, that the machine has not as yet been proven and the cleaning problem of changing colors or materials is both slow and expensive. One of the problems that has to be solved in this regard is the effect of a plunger forcing the plasticized material into the mold would necessarily have some material flow back in the opposite direction from the travel of the plunger and become located between the plunger and the plunger sleeve. This would cause discoloration or possibly contamination in the end product unless some means were developed for its removal. If this particular difficulty can be eliminated, it should result in equipment that would mold at much lower pressures and thereby reduce some of the problems of mold construction on large pieces. Not all molding machines are sold to large plants. There are many concerns that have one, two, four or six machines and it would appear to me that the manufacturer would take into consideration that some of these smaller concerns might find it desirable to have incorporated in the design of their machines, particularly the larger sizes, some safe means of handling molds safely. I think a mounting arrangement could easily be made for a very inexpensive crane for handling heavy molds and that

such a crane could be sold as auxiliary equipment at a very low price safely to handle the heavy molds ad avoid the overhead equipment which would otherwise be necessary for safe handling of molds.

While I am not familiar with the economics of this particular fact, I think it would be possible to build into a machine a refrigeration unit of sufficient capacity to cool the molds and cool the oil used in the hydraulic medium and I think this can be done at a cost that would be lower than the water cost in some localities. It would also make it possible to have definitely controlled conditions and possibly by having these controlled conditions reduce the oil temperature in the hydraulic section below the point that it now operates so that oil sludging can be eliminated. Or, if not entirely eliminated, certainly greatly reduced.

This was called to my attention some time ago by a concern in New England who advised me that their water temperature in the summertime approximated 65 to 70 degrees Fahrenheit. With water of that high temperature being used as a cooling medium, obviously the requirement of a large volume means higher costs as well as inefficient cooling, and I am sure there is ample excess power to operate a small cooling unit which would serve this purpose. Such a unit also could be used for cooling thin cores which otherwise could not be satisfactorily cooled because of the fact that sufficient water at the higher temperature would not carry away the heat with the rapidity necessary for fast operation.

Our maintenance people feel that if the various sensitive controls on a machine such as timers and other fragile instruments of that character were mounted in a separate panel on the machine that the amount of service that electrical equipment would require would be materially lessened if we could avoid the vibration, dirt and oil, which frequently causes breakdowns. If all of this equipment were mounted with the pyrometers on a panel board separately from the machine itself, the shaking loose of screws and adjustments, and the danger of dirt and oil are thereby materially lessened and should reduce maintenance. It would be most desirable if all of the bolts and pipe connections were located in such a place that the ordinary tools could be used for their removal in the event of trouble. Many of the connections in the machines now are located in such spots that it is difficult and sometimes impossible to remove a part for repair without dismantling a large portion of the equipment.

If some of the suggestions that I have made here are adopted, I think they will result in a lower operating cost for injection molding equipment. From our experience with the machines as they are, we have found that we could and have made a large variety of products successfully and profitably, but competition with other materials, such as light metals, is becoming keener all the time and it becomes more important as time goes on that we increase our efficiency and like everything else that we have or do, there is room for improvement in our injection molding equipment.

# RECENT DEVELOPMENTS IN COMPRESSION MOLDING of THERMOSETTING MATERIALS

**By S. D. HILTEBRANDT**

**GENERAL INDUSTRIES, INC., ELYRIA, OHIO**

In the past eighteen months there has been a revolution in the plastics industry. Based on figures covering an estimated 65 percent of the industry, and furnished by S. P. I., July of 1948 was the month in which thermoplastic molders finally passed those molding the thermosetting materials in dollar volume of business per month. Since that time they have constantly led the parade, although they, too, felt the same slowing in business conditions which was experienced this past Spring.

Now, let us examine some of the reasons for this revolution.

Probably the one most important reason has been the development of new injection materials which have extensively widened the markets for plastics. Such materials as polystyrene, polyethylene and nylon have now come into common usage. Also, it now is possible to obtain injection machines of many times the capacity of former machines. Today there are in use a number of machines of 48 ounce and over, while 16 ounce and 22 ounce machines are as common as the eight ounce and nine ounce ones of the war years. Refrigeration and radio engineers, as well as those of many other industries, have investigated and now are specifying polystyrene, methacrylate, and the rest, in new applications to replace metal, glass, and even in some cases the thermosets.

S. D. HILTEBRANDT

At the same time, it is interesting to note that the compression molders, while not bequeathed these new materials with which to open vast new markets, have not been sitting idly back on their fixtures. Despite the growing competition, they have taken advantage of new developments in old materials, larger equipment, and new molding techniques to replace many of the markets lost to thermoplastic materials, or which evaporated suddenly into thin air by an overabundance of household appliances, radios and the like.

Foremost in this advancement on a poundage basis is the development of larger and larger moldings. As recently as October, 1947, an article in Modern Plastics showed progress up to an 11 pound shot and we at General Industries could boast only of a seven pound radio cabinet and an eight pound cash register drawer. Today only two years later, General Industries is mass producing two television cabinets weighing twenty pounds or better and another compression molder is producing a console television cabinet weighing 35 pounds. I know of eight television manufacturers who have authorized construction of 15 or more molds for the manufacture of cabinets and there undoubtedly are others under construction or being molded that have escaped my notice. Television cabinets of 12 to 35 pounds and from 15″ to 18″ deep require extraordinarily large press equipment. Until two years ago there were few if any

presses of sufficient ram travel, daylight, or tonnage to mold parts of this size, weight, and draw. Today we alone have three presses of 1,000 tons or better, and a recent article in Modern Plastics mentions more than 10 presses of over 1,000 tons which have been or are being installed.

Our 1,850 ton press is recessed into the floor ten feet and stands 34 feet overall in its stocking feet. It weighs over 60 tons, but massive as it is, it has a ram speed of over 200 inches per minute. An interesting feature of this instalation is the two 1½ kilowatt radio frequency preheaters used to heat the charge.

The Admiral console television cabinet which has been so widely discussed by the industry, is the largest plastic molding ever produced in the United States.

Designing of television cabinets in plastic provides a combination of inherent advantages which cannot be surpassed in any other material. Foremost, they are inexpensive; they allow for wider variety of decoration at no increase in cost after once incorporated in the die; their finish is permanent and electrically they have none of the disadvantages of metal cabinets. Their one disadvantage lies in the original die cost, ranging in the neighborhood of $20,000 for a single cavity mold. This has, in certain instances, been rather a serious hindrance, as constant design changing in the television industry has caused several companies to shy away from plastic because of limited production of a model before new industry developments forced a radical design chance. Recently, however, the industry has stabilized itself slightly and this, we expect, will sway more manufacturers to the use of molded cabinets.

While television cabinets are at present the most outstanding examples of large-size molding on a large scale basis, they are by no means the only large moldings. Other large parts in current production are a textile drum, circuit breaker base, fishing tackle box and an oil well valve seat. Judging from the acceptance of these pieces, larger and larger thermosetting parts are forecast for the future. As Drew Pearson would say, "Predictions of things to come" include, perhaps, furniture, air conditioning housings, luggage, or a refrigerator or deep freeze case,—who knows?

Another tool which goes hand in hand with the molding of large pieces consist of the new low pressure molding phenolics. These should not be confused with the low pressure laminates, as I refer to phenolic molding compounds which are similar to the present conventional type but can be molded at greatly reduced pressures. Soft materials have always been used by the industry for conditioning molds or on intricate parts to preserve delicate mold details or inserts, but until recently these materials were slow curing and of poor appearance. Now, with the improvement of this type material, we have available a general purpose material which requires only 1/3 the pressure normally used for general purpose material.

Required molding pressures for conventional materials have always been estimated by allowing 3,000 p.s.i. on the projected land area plus 700 pounds for each additional inch of depth. With the advent of radio frequency preheating this rule of thumb was changed considerably. By properly preheating in high frequency equipment and molding in a fast closing press, this pressure can be reduced to 1,000 p.s.i. plus 250 pounds. Low pressure material, however, requires only 350 p.s.i. on the projected mold area plus 100 pounds p.s.i. for each inch of depth when it is preheated electronically.

For example, a piece 6″ x 6″ x 8″ deep when molded without preheat would require 113,600 pounds, when preheated 38,000 pounds, and only 13,400 pounds if the soft material was combined with electronic preheating.

Low pressure molding materials can be used on all size and shape parts, and can be molded by compression, plunger, or three plate transfer. Thickness of section or intricacy offer no problems, and because the material sets fast and rigidly, it facilitates easy ejection and dimensional stability upon ejection. This is uncommon in other soft flow materials.

In order to have these unique flow characteristics, the material must be extremely fluid at a point in its polymerization, and for this reason the fit between the force and chase should be tighter than on conventional molds in order to retain back pressure. Clearance of .003″ to .005″ all around is recommended to prevent material escape and also assist back pressure. The last ¼″ to ½″ of close should be slowed so that this space is traversed in three to five seconds. If these two factors are neglected, shorts, poor surface appearance, and mold staining will result.

Now, exactly what does this low pressure material mean to the molder? First, it allows for smaller, less expensive presses to accomplish the same work where large ones had previously been required. For example, a 300 ton press will mold parts which heretofore had required 900 tons of pressure. This does not mean the press will cost 1/3 that of the former press, as naturally to mold larger pieces, presses of larger platen area, longer stroke, and greater daylight openings are necessary. These raise the cost of the press, but press companies estimate a savings of 50 per cent can be realized.

Secondly, molds do not have to be supported by as heavy chases as formerly, as with lower pressures being used they are not so liable to fracture. This makes possible the use of Kirksite aluminum, beryllium copper, and other alloys. These have not yet been evaluated, but as we have already successfully used beryllium copper in a plunger transfer mold at normal pressure, it is very probable that these molds will be satisfactory. It is not beyond the realm of possibility that a drawn metal shell will even be found adequate.

These materials also offer many advantages in pot type molds where small diameter sprues or long sprues or runners are required. We have normally used about six tons p.s.i. pressure on three plate transfer molds. Since we depend entirely on the pot area to keep the mold closed without flashing, the largest possible area which can be molded in a 200 ton press, allowing a safety factor of 15 per cent, is 28 square inches. Now, with low pressure materials, transferring at two tons, we can mold 84 square inches.

Because of the faster transfer time, it is even possible to have a shorter overall cycle, as the material cures as fast as conventional materials. Mold construction is similar to the regular materials, but all surfaces must be even and parallel, and each cavity and runner should be relieved beyond ¼″ of land. The cavities should be well vented to allow the air to escape in the short transfer time. Practically the same conditions apply for plunger molding as for transfer molding except that here even more than in three plate transfer, we encounter the tendency to flash so that mold surface accuracy cannot be stressed too greatly.

Finally, this material makes possible the molding of even larger television cabinets than already discussed, as now pressure is not the important factor as heretofore. With the large presses being installed and previously mentioned, practically any size cabinet, both table model and console, is in the realm of possibility.

Shortly more than a year ago the Plaskon Division of Libbey-Owens-Ford Glass Company announced a revolutionary new thermosetting molding compound consisting of mineral filler bonded by alkyd resins (poly-

esters). It is my understanding that Dr. Bigelow of Plaskon reported to the last S. P. E. national meeting on the material at that time. As this is the case, I will endeavor to bring you up to date on the more recent developments, but may touch upon some of the points which he mentioned. This is necessary for those of you who are not familiar with the material. One of the strange coincidences in connection with this material is that it has been accepted by the electrical industry, but as yet none of the large custom molders are molding any quantity of it. So far its use is confined to the newer members of the industry or to people molding parts for their own use. Heretofore the greatest use of these resins had been in the protective coating field, although considerable effort had been expended to adapt them to low pressure laminating.

Probably the outstanding characteristic of this new material is its speed of cure, which far surpasses that of any other known thermosetting material. Before the advent of the alkyds, the fastest curing materials required in the neighborhood of 45 seconds, and even then only in thin sections when adequately preheated. Using this new material it is not uncommon to cure parts of up to $\frac{1}{8}$" wall thickness in five or six seconds, and larger sections up to $\frac{1}{2}$" thick in 30 to 50 seconds.

Naturally, where a material cures in a space of seconds the fluid period, too, must be very short, and as the material is a putty-like mass for only approximately two or three seconds, extraordinarily fast presses must be used. These will be discussed shortly.

In addition to this exceptional rate of cure, alkyd has the characteristic of requiring molding pressures of only a few hundred p.s.i. due to its exceptional fluidity over the short span of two or three seconds. Long-draw pieces may require 800 to 1200 p.s.i., but compared with one to three tons p.s.i. for the conventional phenolics, ureas and melamines, the reduction in pressure is considerable.

These two characteristics, fast cure and low pressure, allow for the use of low cost presses and molds. Further reduction in mold costs is also possible as vastly increased production per cavity makes multiple cavity molds unnecessary.

In addition to the advantages of fast cure, low molding pressures and inexpensive equipment, alkyd's dimensional stability is excellent, and its water absorption, from .11 to .16 per cent for 24 hour immersion, is one of the lowest of the thermosetting materials.

Commercial alkyd compounds also have infinitely better track resistance than other plastic compounds. Their arc resistance, ranging over 190 seconds, makes them as much better than the melamines as they in turn were over previous materials. Their dielectric strength (325 to 460 step by step) and heat distortion point (350° to400° F.) are also high. As all of these characteristics tend to point them toward the electrical field, the first applications have been in this direction. Best known at this time is the terminal block and hood of the new Arrow Hart and Hageman magnetic motor starters. This family of devices comprises four models all for 220 volt, three phase circuits, and ranging in capacity from 25 to 200 amperes. Alkyd makes possible starters of half the size of the old conventional type. In the largest the hood and base are massive pieces weighing a total of 5.75 pounds. Curing times are only 25 per cent of those used for the phenolic moldings previously used for these applications. This makes possible increased production per cavity and provides a substantial savings in tool dollars, as the intricacy of these parts make each cavity expensive.

Another application recently developed by the Standard Coil Products Company is a television tuner. Here 24 segments provided with five or six contact buttons which are soldered into position after molding are assembled to form a drum 3" in diameter. This drum, when rotated, makes contact with a permanent set of terminals and provides a series of 12 connections, each of which brings in a different television channel. Because of the sensitivity of a television receiver, tolerances of $\frac{1}{2}$-thousandth inches per inch must be held. Here, also, heat resistance is important, as the silver contacts are soldered and hot solder comes in contact with the plastic. These parts are being molded on an eight-cavity mold at the rate of 960 per hour, with a cure time of 20 seconds.

In addition to these jobs just described, there are many others of a similar nature already in use. Several plants have already put in a battery of specialized presses and are in production of alkyd molded parts.

Among the special presses now being, or about to be, offered are the Baker, Denison and Elmes. The Baker Automatic high speed presses have total pressure of either six or ten tons with a ram stroke of 8" and a speed in excess of 360 inches per minute. The platen is activated by a double stage Vickers pump with an unloading valve and Greer accumulator to save power and to avoid overheating. The unit is powered by a five h.p. motor. A three cavity horizontal feeder with a feed capacity of from nine to 70 cubic centimeters per cavity is provided. Each feeder is independently adjustable over the entire range to provide for distribution of load in any manner over the whole mold surface. The press is fully automatic and is controlled by a single limit switch.

Preliminary tests of the six ton machine at Square D on a 21 gram terminal block gave phenomenal results. For example, where the part had formerly been produced in a 12 cavity mold at a rate of 5500 pieces in 24 hours when pre-formed and electronically pre-heated, the rate was equaled in alkyd from a three cavity mold in 16 hours. Pre-forming and electronic pre-heating is eliminated and the automatic operation of the press makes it possible for one operator to tend several machines.

As data on other presses is not as yet available, it will suffice to say that when announced they will no doubt be of a similar nature to the Baker.

This information on the air-actuated press does not by any means imply that present hydraulic presses cannot be used, but if they are, several modifications should be made for best results.

1. The daylight opening should be adjusted to the minimum required for loading and ejection of the piece.
2. Under no circumstance should the closing time exceed four seconds.
3. Reducing valves should be utilized to allow for the ultimate condition of 800 to 1200 p.s.i.
4. Mold temperatures should be reduced to from 250° F. to 300° F., depending on the volume of material and rate of cure desired.

While alkyd is not generally adaptable to transfer molding, flash semi-positive and postive molds are satisfactory.

In addition to their 420 just discussed, Plaskon has already announced Alkyd 411, which is supplied as a putty and is readily extruded cold into ribbons or other required shapes. This allows the molder to pre-assemble a condenser or resistor and then mold a shell around the delicate assembly — a shell which is stable, moisture and heat resistant.

These two materials, the granular and the putty, are merely the forerunners of a whole family of materials which eventually should include light colored general purpose

impact, heat resistant and others. Many of these have already been made successfully in the laboratory, but until large scale production facilities are available they cannot be offered commercially.

The present materials have several inherent disadvantages which, until they are overcome, will limit their market. First, they are expensive, 35c in 10,000 pound lots. Their gravity is 2.2, which serves to raise the price on a number of pieces per pound basis, as against the lighter plastics. They have a tensile of only 3,000 to 4,000 p.s.i.; a flexural of 8,000 to 10,000 p.s.i. at room temperature; and at 300° F. of 4,000 p.s.i.; and an impact of .30 to .35 foot pounds per inch of notch.

In addition to the facts which I have just presented you on larger molding on low pressure phenolics and on the alkyd materials, there are also the new fast-curing phenolics which have enabled us to cut the cure on present production from 15 to 45 seconds, depending on the piece. Then, too, plunger molding is daily finding a more widespread use and this process, too, is aiding the progress of the thermosetting molder. No, thermosetting materials are not passe, they are not on the way out. Fact of the matter is, they are still a very important part of our industry, and these new developments will, in time, bring about their even wider usage.

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# CONTINUOUS LAMINATING OF REINFORCED PLASTICS

By STANLEY M. CASH

CONTINENTAL CAN CO., INC., CAMBRIDGE, OHIO

## INTRODUCTION

The purpose of this discussion is to define a laminated reinforced plastic, describe its component parts, discuss the principles of the continuous laminating process and the type of mechanical equipment required. In addition, comments will be made on the various controlling factors essential for successful production together with brief mention of the evaluation methods used in the final product. Comment will be made on the end uses of continuous laminated plastic products.

## WHAT IT IS

Before discussing something, it is desirable to define what we are talking about. What is a reinforced plastic? A resinous material in which an organic or inorganic filler is incorporated can be defined as a reinforced plastic. A laminated plastic also falls in the category of reinforced plastic. At this point, we might well ask ourselves what is meant by the word laminated. To laminate means the building up of a material in plates or layers. Therefore, by derivation, we arrive at the final definition of laminated plastic which is — a plastic resin reinforced with a filler material built up in layers.

## WHAT IS IN IT

What is in the material might well be the next logical question after we have defined it. The fillers or sheet materials used to build up the layers in the laminated structure are

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such as phthalic anhydride with a glychiefly cellulose fibers either in the form of cotton fabric or paper. Inorganic fibrous materials such as asbestos and glass are also used. Synthetic fibers of nylon, rayon and others are used to a much lesser extent.

The binder component for the filler materials of the laminated plastic, in so far as this discussion of continuous laminating is concerned, is the so-called polyester resin. Polyester resin is a liquid material varying from a relatively thin liquid of 50 to 100 centipoises viscosity at room temperature to a very viscous material of 75,000 to 100,000 centipoises at room temperature. The commercial resins now being supplied are practically water white. This type of resin is made from the basic chemical reaction of a di-basic acid such as phthalic anhydride with a glycol such as diethylene glycol. The final resin is the result of the copolymerization of this reaction product with a vinyl compound such as styrene. In the presence of a peroxide catalyst active polymerization takes place upon heating to form a hard thermoset material. This reaction is exothermic and as a result, considerable heat is evolved during the cure of the resin as conversion from the liquid to the solid state takes place. Theoretically, no gaseous products are given off when this irreversible chemical reaction produces a thermosetting compound. This characteristic produces excellent physical properties in the resins without the use of pressure. This is the key to use of polyester resin in continuous laminating.

## HOW IS IT MADE

Now that we have defined the material we have been talking about and have discussed its component parts, let us look into how it is made. Continuous laminating of multiple layers or plies has long been practiced in the packaging industry where plastic films, metallic foils or different types of paper have been laminated in various combinations. In such applications, the plies are not completely saturated with a resinous material but are usually surface coated for the purpose of gluing or bonding the various laminates together to form the final structure. This type of operation can usually be carried out at a comparatively high rate of speed since the lamination is effected by

either removal of moisture and combining roll pressure or combining roll pressure only. Continuous laminating of reinforced plastic is quite another story because successful lamination requires careful selection of binder and filler materials and close control of a complex chemical reaction during the laminating process.

A. Selection and Preparation of Resin

The selection of the resin to be used for laminating purposes depends upon the final characteristic desired in the laminated product. In addition the working characteristics of the resin, the kind and absorption rate of the fiber together with the limitations of the mechanical equipment must also be considered.

In the case of decorative laminate a resin is required which will impart excellent color, good stain and abrasion resistance and low moisture pick-up characteristics to the finished product. In the production of laminates for industrial use, such characteristics in the final product as flexibility, flame resistance, impact strength and other mechanical properties as well as electrical insulation values must be considered in resin selection. The polyester resin can be modified by the manufacturer in order to supply the laminator with a resin having special properties to meet the requirements of certain characteristics in the final laminated product.

The laminator usually has his own idea of the best resin viscosity for a specific job. This is determined by filler characteristics and mechanical equipment. It is customary to use two or more different resin viscosities. The resin can be purchased to viscosity specifications or a viscous base resin may be used and diluted with monomeric styrene as required.

As previously stated, these resins polymerize or "cure" in the presence of a catalyst and heat. In preparing the resin for use it must be catalyzed. One of the organic peroxides such as benzoyl peroxide is most commonly used. The peroxide or BPO may be obtained in granular or paste form. After thorough mixing of the catalyst into the resin, it is ready for use. The life of the catalyzed resin at room temperature may vary from several hours to several days. Immediately upon being catalyzed, the inhibitors, added by the manufacturer in order to stabilize the resin, are being progressively consumed by the catalyst. Refrigerated storage slows up the effect of the catalyst on the inhibitors and prolongs the "tank life" of the mixed resin.

B. Selection of Fillers

Paper is by far the most widely used filler in laminated plastic. This is chiefly due to economics. The polyester resins were first commercially used during the war. The applications were 100% for military requirements in which fiberglas and cotton fabrics were almost entirely used as filler materials. Little or no knowledge of paper laminating was available when the post-war development era began. Because of the discouraging results obtained at first with polyester paper base laminates, particularly in respect to moisture pickup, many people were convinced that paper was not a suitable filler material for these resins. Subsequent development and research have shown this opinion to have been false.

Paper to be used in continuous laminating must be smooth in finish and properly balanced between tensile strength and absorptive characteristics. Once these characteristics in a given paper stock are worked out, it is essential that the source of supply be able to maintain uniformity from run to run of paper. Lack of uniformity in paper has been an expensive and troublesome problem to laminators.

In decorative laminates different kinds of paper must be used for core stock and design printed surface. The core stock is usually an unfilled paper, i. e., contains no mineral filler and is soft and absorptive. The paper on which the decorative design is printed is a pigmented or filled stock. This is necessary to give opacity. This paper must have good printing as well as saturating properties. These two characteristics do not usually go hand in hand.

As can be seen the foregoing, not just any paper will do. Proper selection and unifomity of the paper filler is just as important as the resin itself in the effect on the final laminated product.

C. Cover Sheets

In the production of laminated plastic, either by the press or continuous method, it is necessary to have a protective surface in contact with the face or outer plies of the laminate. In the press method of laminating, either stainless steel or copper plates, called caul plates, are used between each laminated buildup to impart surface finish and separate the various laminates one from the other when multiple laminates are cured simultaneously between press platens. In the continuous process the common practice is to feed into the machine simultaneously with the webs being laminated a top and bottom cover sheet. Cellophane is the most common material. However, various coated papers have been used with varying success. In continuous laminating, the cover sheet usually serves three functions, namely: (1) protects the polyester resin from air during the polymerization stage since air inhibits the "cure" of the resin, (2) serves as a protective surface for the laminate and hence produces a glossy surface on the laminate because the resin "cures" in contact with the cellophane and (3) acts as a carrier for the laminate as it passes through the oven section of the laminator.

To date, cellophane has been most successful material for this purpose because of its toughness and shrinkage characteristics which cause it to become highly taut as it passes through the oven sections. This aids materially in the production of a flat laminate. Cellophane has many disadvantages but no other material has as yet proven as satisfactory.

D. Mechanics of Continued Laminating

As the name implies, continuous laminating of paper or fabric filler materials is done from roll stock: (1) The laminating machine is equipped with a number of unwind

stands usually placed in tandem. Rolls of the filler stock being laminated are placed on these unwind stands.

(2) Material from the rolls is unwound and carried through saturating tanks containing the resin. There is a separate set of saturating tanks for each web or ply of material making up the laminate.

(3) As the various webs or plies of material emerge from the saturating tanks they are brought together at the nip of a pair of combining rolls. The top and bottom webs of the cellophane cover sheets are also fed in at this point.

(4) The combining roll unit is a very successful part of the laminating equipment. The rolls regulate the thickness and amount of resin in the final laminate. The contact between the rolls must be adjustable with a high degree of accuracy. The rolls must be of sufficient mass to prevent bow or spring when set down on a heavy laminate.

The roll setting depends upon the type of material being laminated. It is common practice to set the rolls .001 in. or .002 in. under the actual thickness of the filler material plus the thickness of the cellophane. The thickness of the final laminate will usually be .005 in. over the actual thickness of the material being laminated. However, this varies considerably with the density of the filler stock. The average resin content of a continuous laminate is about 55%.

(5) As the laminated material emerges from the combining rolls between the top and bottom cellophane webs, the outer edges of the cellophane webs are picked up and tightly clamped in a set of tenter chains which carry the laminate through the oven sections of the laminator. It is customary to use cellophane wider than the laminate being produced. The laminate, therefore, is actually suspended between the cellophane as it passes through the oven.

(6) The oven section of the the continuous laminator is highly important for success or failure in production is largely dependent upon the oven. The ovens are usually heated by circulating hot air obtained from either electrically heated or gas fired units. It is essential that the ovens be divided into independently controlled zones to provide gradually increasing temperatures as the laminate is carried along. The temperature control units on the oven must be capable of maintaining uniform heat within each temperature zone. Uniform temperature control is highly important because of the complex reaction which takes place as the laminate is carried along. Each stage of the reaction must occur in the proper temperature zone or blistered laminate may result. It is just as important that heat be removed from the laminate during the exothermic reaction as it is necessary to supply heat to initiate polymerization. Therefore, adequate air circulation is essential at the point of exothermic reaction. The usual range of temperature employed in the primary oven zones is 160 - 180°F., 190 - 210° F. in the intermediate and 250°F. to 275°F. in the final zone.

(7) After the laminated web has passed through all stages of the oven it emerges as a rigid material which can be cut to sheet lengths as desired. In general, 1/16 in. thickness is considered the practical upper limit in thickness of continuous laminate. It has been found that laminate under 3/64 in. can be successfully wound and shipped in rolls.

E. Controls Necessary for Successful Production

Successful production of continuous laminate is dependent upon careful checks on the filler materials, resins and machine operating conditions.

(1) Controls on Fillers

One of the most important properties of paper filler materials is absorption or saturation rate. An adequate means of evaluating this property in the laboratory has presented quite a problem. Recently a method has been worked out utilizing a column of mineral oil over a diaphragm of the paper being tested. Time is measured for oil to penetrate the paper diaphragm. This is a comparative evaluation. The mineral oil is more satisfactory than resin because it is not subject to evaporation losses and subsequent increases in viscosity. By this means of measurement a saturation specification for the paper mill can be set up to insure uniformity in the paper.

(2) Controls on Resins

Resins control presents several problems. All incoming resin as received from the supplier should be inspected for viscosity, gel time and tank life. By gel time is meant the time in minutes usually from 150°F. to the peak of the exothermic reaction. This is best obtained by measuring a given amount of catalyzed resin into a test tube and placing a thermocouple in the tube. The tube is placed either in a water or oil bath and maintained at 180°F. The thermocouple is connected to a recording instrument which draws a continuous curve. The polymerization reaction is usually initiated at from 165 to 180°F. Most resins reach a temperature of 350 to 400°F. as the peak of the exothermic reaction is passed. The curve presented on the chart is called an LPE cure (liquid-peak exotherm). This curve is highly important as it is a direct measure of the resin reactivity. The curve may become considerably shorter after the resin has been in storage several months. However, most commercial resins today are quite stable for 6 months or over at temperatures under 80°F.

The term "tank life" means the length of time catalyzed resin remains in the liquid or usable state at room temperature. This value is important from the standpoint of machine operation where several hundred pounds of catalyzed material remain in the saturating tanks at the end of a day's run.

Viscosity and gel time tests are a necessary part of the routine controls which must be maintained on all resins being mixed and delivered to the laminating machine.

(3) Operating Controls

The most important machine controls are speed and temperature. It is highly important that the exothermic reaction of the resin occur at a definite location in the oven. Speed of the machine and oven temperatures must be so bal-

anced as to control the exothermic reaction. The speed of machine operation is also limited by the saturation rate of paper being used. Most laminating is done at speeds less than 10 feet per minute.

F. Evaluation of Properties of Finished Laminates

Evaluation tests depend largely upon the end use of the product. Most tests are conducted in accordance with ASTM Standards. However, some methods have been developed to meet certain characteristics not covered by established standards.

Decorative laminate should be checked at frequent intervals for heat and abrasion resistance during manufacture. Other laboratory tests of evaluation include water absorption, dimensional stability and resistance to certain stains.

Various types of industrial laminates must meet certain tests peculiar to the end use of the material. For example, laminate destined for electrical insulation applications must be tested for power factor, dielectric constant, loss factor and dielectric strength. Physical properties of the material such as tensile, flexural, compression and impact strength are also required. All these properties both electrical and physical are evaluated by A.S.T.M. Standard methods.

## WHERE IT IS USED

This is the logical conclusion to all that has gone before.

Decorative laminate is used primarily as horizontal surfacing material such as dinette table, sink and counter tops. It has not made much headway on vertical surfaces chiefly due to cost and difficulty of installation.

Industrial laminate is considered any material not used chiefly for its decorative value. Industrial laminates are made from all the usual filler materials either alone or in combinations. One of the principle uses of industrial laminates is in the electrical insulation field where the material is hot or cold punched into many intricate shapes and sizes for incorporation into a myriad of electrical equipment. Paper base laminate is the bulk of the material used in the electrical field. Fabric base laminates can be heated and subsequently postformed into various shapes by means of forming dies.

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# MACHINERY FOR PLASTIC COATING

By ARTHUR GAIO

JOHN WALDRON CORP., NEW BRUNSWIGK, N. J.

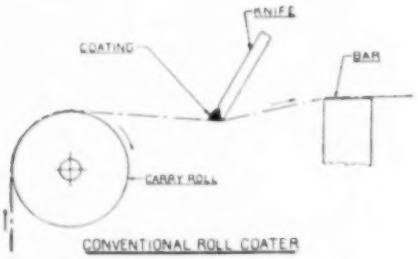
The knowledge and experience acquired during the critical war years in developing protective and decorative coatings has begun to bear results which few of us dreamed possible. Not only new materials, but modifications and improvements in old ones are increasing with such rapidity that it is impossible for a person to keep thoroughly informed or to comprehend their total significance. This rapid advancement has made more pronounced the problem of selecting the coating machine most suitable in applying a particular type of coating.

The following descriptions, together with the illustrations, are designed to facilitate the understanding of the four general types of coaters used for plastics, namely, knife, roll, air and cast coaters.

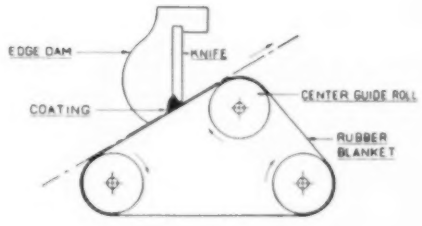
### Knife Coaters

There are three important knife coaters worthy of mention.

The first of these is a simple coater, frequently called a **floating knife coater.** The coating is applied onto the face of the web, in front of the knife, employing dams or end plates to resist the lateral movement of the coating. Since the knife is supported only by the web, the coater is unable to handle low strength materials. The angle of the knife should be inclined from the vertical in the direction of web travel, since the hydraulic action of the coating would tend to force the coating past the knife or break the web. The tension on the web should be set at the worst condition since the tension will vary considerably during the coating operation. The thickness and quality of the coating applied by this coater is controlled by the angle of the knife, radius of the knife, and tension on the web. Any slack edges and varying caliper are a detriment to uniform coating. This coater finds its greatest usage in the textile field in the application of organisol and vinyl coatings.



CONVENTIONAL ROLL COATER



KNIFE COATER

The second or **blanket type knife coater** employs a solid rubber blanket as a carrier for the web and support for the knife. By using a rubber blanket, low strength materials can be coated, since the tension is removed from the web and transferred to the blanket. The fact that the tension is applied to the rubber blanket results in uniform pressure on the web. This factor permits more uniform coating than that obtained on the previously mentioned floating knife coater where all the pressure was applied on the web. Since the rubber blanket exerts a constant pressure on the web against the knife, the coating will be applied uniformly regardless of varying caliper of the web. This pressure can be pre-set and adjusted during operation without changing the tension of the web.

The third or **rubber spreader** employs a knife mounted above a rubber

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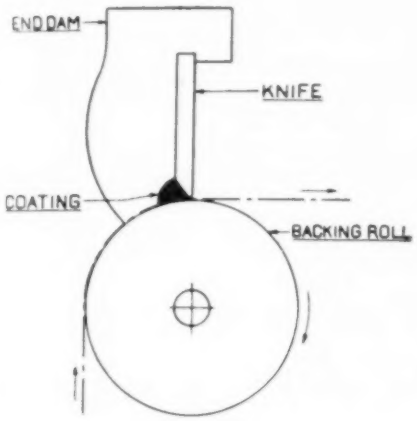
roll. The viscosity of the coating and the density of the rubber roll should be properly proportioned so that the rubber roll is always under pressure. This results in constant and uniform pressure on the web against the knife tending to offset minor inaccuracies in the knife, rubber roll, and the web. If this is accomplished, results may be obtained comparable to those obtained on the blanket coater.

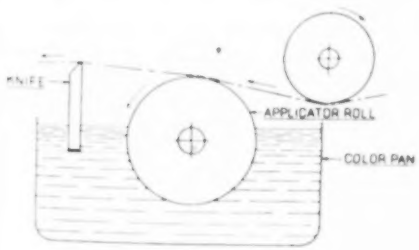
When discussing knife coaters, the design and shape of the knife should




ROLL KNIFE COATER

be considered since it assists in controlling the quantity and quality of the coating. The larger the radius on the knife, the greater the amount of coating which is applied. Avoiding so called "spitting" can be accomplished by specially designed knives, which have a right angle cut to the radius of the knife. The web should leave tangent to the radius of the knife and perpendicular to the cut in the knife. The angle of the knife should be inclined from the vertical in the direction of web travel.

One great objection to knife coaters in general are the streaks which are caused either by particles be-




KNIFE COATER

coming lodged under the knife, or the abrasive action of the coating which causes scratches on the knife. By using a highly polished, hard chrome finish on the knife, the streaks caused by scratches on the blade can be held to a minimum.

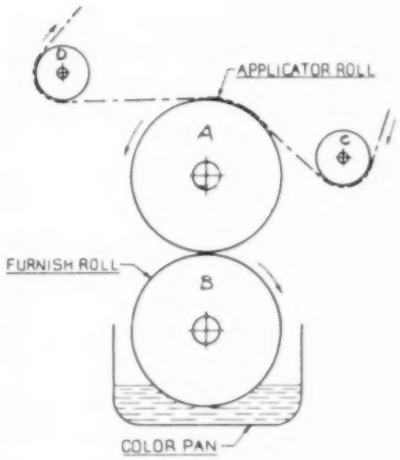
Knife coaters are used principally in the application of high solid content materials, such as vinyls, organisols, rubber, etc., as well as lacquers, varnish and shellac.

### Roll Coaters

There are many types of roll coaters but only the more important of these will be discussed.

The **doctor kiss coater** is a combination of both the knife and roll coaters. It employs a roll application of the coating in conjunction with a knife that meters and smooths the coating.

This coater finds its greatest success in the application of low solids and low viscosity coatings. It has found widespread use in the application of coatings to embossed or rough materials. Since the coating roll can be rotated in either direction, it applies coating in considerable excess, forcing the coating up into these impressions or irregularities. The knife by means of capillary attraction and gravity permits a uniform coating on these rough surfaces.

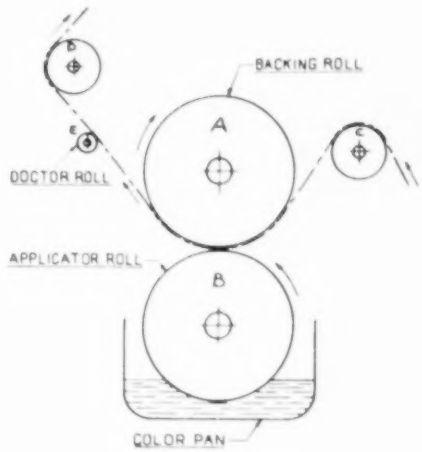



KISS ROLL COATER
GUMMER TYPE

The Germans were using this method of application with great success in the manufacture of Condenser paper employing a Nitrocellulose Methyl Acetate coating.

A second type or **roll kiss coater** employs two identical rolls, one rotating in a pan of coating, the other being mounted in a vertical plane directly above. In order to secure better control of the tension, and a greater arc contact with the coating roll, rolls C and D are placed on either side of the top roll. Under certain conditions air may be carried through between the web and coating roll A resulting in "skip" coating. This condition may be remedied by applying weights on top of the web at roll A or by placing a rubber roll at this position.

Kiss coating will give uniform coating since the mechanical inaccuracies of the rolls is reduced when the coating film is split twice. The coating as it leaves the nip of rolls A and B splits and splits a second time at the nip where the web leaves the surface of roll A. It is a good method of application if you are coating just one side of the material, since there is no danger of coating the back side of the web.



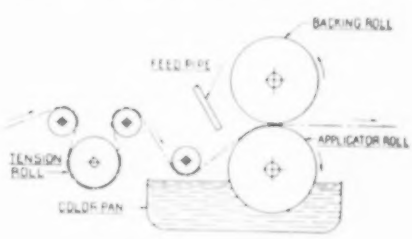

ONE SIDE ROLL COATER

There are three sources of difficulty to be watched for in this coater; namely, tension, slack edges, and air carrying through between web and roll.

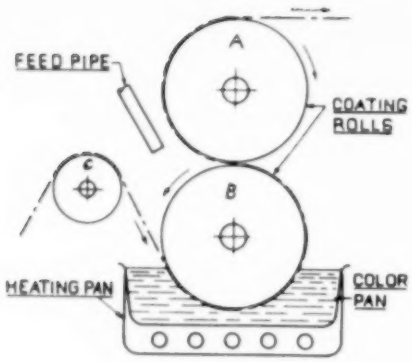
This type coater finds its application in the field of hot melt coatings.

If the above machine is rethreaded so that the web passes between rolls A and B, **one-side pressure coating** can be effected. If the two chilled iron rolls are ground true, the coating will vary as the web varies in caliper. By replacing roll A with a rubber covered roll of the proper density, a more uniform coating can be obtained.

In designing wide roll coaters, large diameter rolls become necessary to avoid possible sag. The large diameter rolls and the surface tension




TWO SIDE ROLL COATER




TWO ROLL COATER
SQUEEZE ROLL SATURATOR
OR TREATER

of the coating cause large ribs. These coarse ribs may be reduced to finer ribs by contacting a small diameter roll, such as E, after the coating has been applied. Roll E being of smaller diameter produces finer ribs, since the angle of tangent with web is reduced. Roll E is usually run in a direction and speed best suited for the particular job.

The pressure coater has the danger of applying some coating on the back side of the web. If coating on the back side of the web is not conducive to continued operation, roll A should be a metal roll. A cleaning doctor could then be used on this roll which would assure a clean roll coming in contact with the web at all times. This coater finds application in the fields of wax and hot melt coatings.

By rethreading the above machine so that the web is wrapped about rolls A and B with the addition of a feed pipe, **two-side pressure coating** may be accomplished. This coater has the same advantages of the one side pressure coater. It is, however, more adequately equipped to handle low strength materials, since the pressure rolls and the coating assist in driving the web through the coater. This was not true of the previously described roll coaters. The web could be threaded through rolls A and B providing a strong material is used. Basically, this machine is used as a saturator or impregnator. It is extensively used in the field of phenolic coatings.

One of the more recent developments in the field of roll coaters is the **edgewise coater.** A roll pressure method of application, built on a vertical plane, is used to apply the coating to the web. Either a one side or two side coating may be applied since the coating is pumped to the top of either or both sides of the web and permitted to flow down forming a nip at the rolls. Prior to its development, the coating was applied by means of tower coaters, which depended on a dip and gravity flow method of application. Since the material being coated could not be contacted on either side, the height of the tower or dryer determined the production speed. This was in the neighborhood of from one to three feet per minute. Present day edgewise coaters operate at speeds of 150 feet per minute.

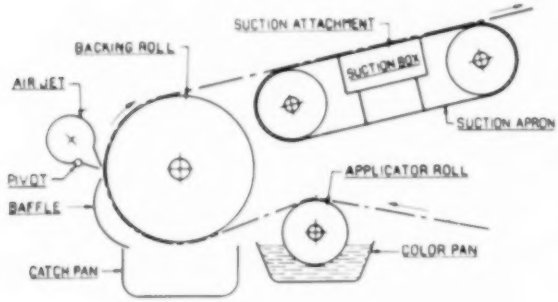
Of the roll coaters, the **reverse roll coater** is the most flexible. The thickness of the coating cast onto the web is governed either by the opening between the doctor and casting rolls or by changing the speed of the casting and doctor rolls in relation to the web speed. This means that the greater the differential between the web and casting roll, the greater the amount of coating that will be cast on the web.

The doctor roll is mounted on micrometrically adjusted bearing blocks, which permits accurate adjustment during the coating operation. The coating is cast on the surface of the web, the web being held against the surface of the casting roll by a resilient synthetic rubber backing roll, which is also micrometrically adjusted for various caliper materials. The various speed ratios and reverse rotation between the doctor and casting rolls minimizes ribbing. The surface tension of the coating will govern the speed ratio between the doctor and casting rolls. This coater is capable of handling low strength materials as readily as the strong materials, since the web is not subjected to material tension or pressure. Since the coater uses a casting principal to apply the coating on the web, the varying caliper of the web does not affect the uniform thickness of coating being applied. It is interesting to note that given a coating formulation consisting of 50% solids by weight, we could apply say a one thousands dry film on the web by having a two thousands opening between the doctor and casting rolls. A few of the more notable coatings applied by this method include organisols, vinyls, lacquers, varnish, and most solvent type coatings.

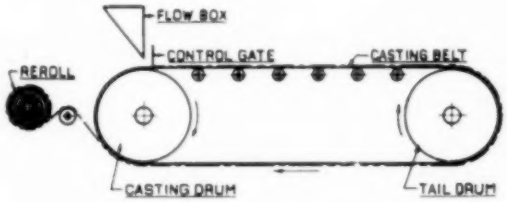
### Air Knife Coater

The Microjet or **Air Knife Coater** is a very recent development, although the use of air as a metering means was understood and attempted years ago. This is one of the improved practical applications. The coating is applied to the web in a regulated excess by means of a reversible variable speed drive on the coating roll. The slotted air blade, which is micrometrically adjusted for uniform slot opening at various positions along the blade distributes the coating and planes off the excess. The air nozzle is angularly positioned by rotating the nozzle about a pivot line which is located at the slot opening of the nozzle. The slotted nose of the nozzle may be positioned in relation to the backing roll by a horizontal adjustment in order to accommodate the various caliper webs. The amount of coating applied is controlled by the air pressure and utilizing the variable speed of the coating roll to supply a regulated excess of the ultimate weight of coating desired. The minimum weight of coating depends on the absorbency of the sheet, since the coater is capable of blowing off the major portion of the surface coating. The "Microjet" is one of the most versatile coaters, being able to handle a wide range of viscosities. Its simplicity of operation results in low maintenance costs and permits the use of inexperienced operating personnel.

Because of its recent development, the coating possibilities of the air knife coater have not been completely exploited. It has, however, shown




MICROJET COATER




BELT CASTING MACHINE

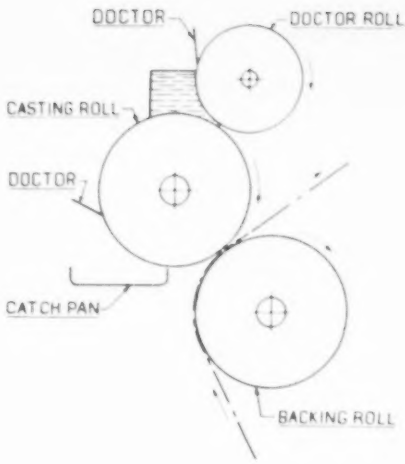
excellent results with water dispersions such as "Geon" and "Saran." Very promising results have also been obtained with wax, organisol, vinyl, rubber latex and many others.

### Cast Coaters

There are two cast coaters worthy of mention:

The first of these is called a **casting drum coater,** since the coating is applied to the surface of a highly polished drum or cylinder. The head or flow box controls the amount of material supplied in front of the knife. The flow box is usually under high pressure and temperature. The control gate acts in much the same manner as a knife in metering and leveling the coating on the cylinder. This type of machine is usually used in the manufacture of acetate and photographic films.

The second of these coaters is called a **casting belt coater** and employs the use of an endless steel belt as the casting surface. Much the same casting equipment is used as in the previously described cast drum coater. The cast belt coater has wide use in the manufacture of vinyl film. A machine similar to this, with some minor additions, is now in operation producing a fabric laminated to Cellulose Acetate. It consists principally of an oven containing banks of infra-red lamps and a stainless steel belt on which the Cellulose Acetate molding powder is automatically weighed and cast. The acetate powder is preheated to a sufficient temperature by the infra-red lamps. The fabric is introduced at the opposite end of the oven so that steel belt, molten Cellulose Acetate and fabric pass through two pressure rolls, which combine the fabric and acetate. The material is stripped from the belt at the cool end of the oven. This process eliminates the use of solvents and produces a product which can be drawn into a variety of shapes, in ordinary hydraulic presses.




REVERSE ROLL COATER

When one considers the tremendous technical advancements and the new plastic coatings being made available in ever increasing number, the selection of the proper coater becomes all important. The machines previously described have definite advantages as well as short comings. There is no one type of coater on the market today, which will solve all coating problems. Coaters are designed to handle the particular material being processed.

One must consider the end results desired, the nature and flow characteristics of the coating as well as the economics of the problem. After all, the application of a coating is only a means to an end and any effort expended to understand the relationship which exists between the coating material and the coating process will benefit both producer and consumer.

# LONG-WAVE RADIANT HEATING FOR PLASTICS

By THOMAS WALSH
SILL INDUSTRIES, NEW YORK, N. Y.

The great growth and ever-increasing momentum of the plastics industry is bringing the need for better processing equipment into increasingly sharper relief. Among the industry's many needs, none is more important that heat — for heat is basic for most plastic processing. When you consider the drying of resin crystals and powders, the molding and forming operations, the drying and curing of spread coatings, the need seems universal.

Before the advent of plastics there were bake ovens and air ovens and not much else. Some of the latter were limited as to temperature and operations were performed at a speed ratio commensurate with oven temperatures. Operations were costly as well.

From the standpoint of the heating engineer, the needs of the plastics industry seem to be these: higher and more uniform temperatures, better control of those temperatures and lower operating costs.

Under discussion is one of the newer developments in heat for industrial processing. This heat is developed differently from other types and that difference has proved important to many segments of your industry.

The heater itself is called the Fibre Glass Super-Heater. Using fibre glass in four different forms it really named itself. In effect, it is a radiant heating panel built to any size to suit any operation.

Briefly, it has four major advantages for plastics operations. First, and most important, it develops completely uniform surface temperature — every square inch is radiating the same temperature. Secondly, the temperature can be controlled at any point in a range from 120° F. to 700° F. Thirdly, the heat developed is black heat in the infra-red range. As you know, the black heat ray is definitely longer and more penetrating than the incandescent or visible infra-red. Fourth, the cost of operation is so low that in many areas it compares favorably with that of gas or steam.

A word on construction is important to an understanding of why it works as efficiently as it does on plastics in its many forms. These are resistance-type units employing Nichrome V wire which is closely woven through a mat of fibre glass tapes and tubing. The tapes are stretched taut over aluminum frames and the surface is a fibre glass blanket. The heat developed in the wires under this blanket, therefore, has only to pass through the surface blanket to get to the material to be processed. The transfer of the heat is virtually 100% efficient. The balance of the housing contains fibre glass insulation.

Suppose we examine the Super-Heater in terms of specific plastic operations.

After some two years of processing applications it is debatable whether the first units were used on coatings

or on plastic sheets. In the case of the latter, these heaters seemed ideal for pre-heating acrylics and acetate sheets because uniformity of heat was a "must." The Industrial Radiant Heat Corporation therefore developed a vertical and a horizontal piece of equipment to pre-heat plastic sheets prior to molding. The vertical model was designed to apply the heat on both sides and handle sheets from ½" gauge and up. The horizontal unit is for sheets of lesser gauge. As an example of the vertical operation, a sheet ½" thick is ready for forming in 4 minutes. There are no hot or cold spots, no distortion, no blushing and no rejects. The same is true of the lesser gauges only the time cycle is faster.

The heat can be applied by contact or otherwise. It is equally efficient both ways.

Vacuum molding has come into prominence in the past year or so and for this operation the Super-Heater would seem to be pre-eminent. Using 10 mil translucent vinyl the optimum time cycle was 10 seconds; on 20 mil vinyl, 20 seconds. On planished transparent vinyl the optimum cycle for 10 mil vinyl was 12 seconds and on 20 mil 15 seconds. Other types of heat application on these same sheets had an optimum cycle of 1 minute to 2¼ minutes.

Bending sheet plastics seems to have been a chore, particularly with distortion at the bend. The company thus was led to develop the Line Heater, a narrow single wire heater that pre-heats a path ½" wide along the sheet surface. Usually operating at 600° F. it heats a sheet 3/16" for bending in less than 2 minutes, providing a quick, clean bend without distortion. So much for sheet plastics.

The subject of spread coatings is infinite, so we will hit only a few high spots in the major classifications of the organosols, plastisols, latices and remelt lacquers. Here again, the primary need of the entire field is uniform application of the heat, both for drying or curing. It is in this classification of plastic processing that the Fibre Glass Super-Heater first came to the attention of leading industrial processors everywhere.

It started with the curing and embossing of plastisol coatings on fabrics. This operation formerly was done in the conventional method which required multiple passes of the material in order to get the necessary coating thicknesses, in a range from 6 to 32 dry ozs. per square yard. The method was subsequently changed. Super-Heaters were installed and all coatings were put through in a single pass, curing and embossing at the same time. The 6 and 8 oz. coatings went through at 35 yards per minute and the heaviest coatings at 8 to 10 yards per minute. Quality was improved, multiple handling eliminated and volume materially increased.

It is interesting to note that no housing is required. The operation is open and fumes are exhausted at the sides of the heating units. Organosols on fabrics are handled in the same manner. It takes a high temperature, uniformly applied radiant heat to achieve both the speed and high quality that are only possible by this method. Incidentally, this operation is run with an input requirement of 45 KW per hour. At a figurative 2c rate, the cost of operating the Super-Heaters would be 90c per hour. This is low in anyone's language. Incidentally, again, the 100′ oven operation can now be done with a coating machine that measures 24′ from unwind to rewind.

This type of setup will handle about every type of coating job with a change of coating head. Ethyl cellulose, nitro-cellulose,, vinyls, and remelts on paper are handled identically. In processing remelts, this heat produces a sheen that is second to none and has all the appearance of a cellophane finish.

Super-Heaters make a safer operation where solvent-laden air ordinarily may be hazardous, for it is never able to accumulate due to the blower and duct action. Furthermore, the black heat is an asset in such circumstances.

In many plants where existing equipment includes an air oven, it is a simple matter to do a curing job as well. The addition of two or more radiant heating panels at the delivery end of the air oven forms a complete fusing section without changing the operation in any degree. Two 5′ panels are usually sufficient to provide for average operating speeds. Also, the operating position may be vertical to save valuable floor space. The investment is commensurately small.

The embossing of unsupported plastic film gauging 2 mil to 22 mil is now a subject of greatest importance to scores of plants. This operation was formerly thought to be done best by embossing with male and female engraved rollers, heated and operating under high pressure.

The latest and best procedure preheats the film itself and uses a chilled engraved roll operating against a paper or rubber roll. This freezes the pattern in the film and two chilled rolls complete the operation. This is really molding instead of embossing but the results are deep and clear and that is what counts. This operation is done extremely well with a stainless steel wire mesh belt acting as the carrier for the film. It positions the film perfectly, gives it the dimensional stability needed to bring it through the heat and into the nip of the embossing roller at the right temperature. The Super-Heater is positioned underneath the mesh belt and the embossing roller is underneath the rubber or paper roller. Speed of operation is 8 to 30 yards per minute, depending on gauge of film. This setup runs steadily without wastage of precious film, with a uniformly-deep embossing from selvage to selvage.

The newest machine for really high speed embossing is that developed by Marc A. Chavannes. This unit employs an endless nickel-copper alloy belt as the film carrier and will deliver speeds of 150′ per minute and up. This operation utilizes 6 Super-Heaters and is the machine for large volume operations.

Press embossing also employs Super-Heaters for that all-important factor of uniform heat application and particularly control. It has been established that the job is done on supported and unsupported film without plate marks and at faster speeds than formerly.

The automobile seat cover of woven plastic materials is another product that was formerly processed with some difficulty. Now it is finished much like plastic film is embossed. The Velon, Saran or Polyethylene is pre-heated and calendered with cold calender rolls. The heat and the calendering give it the fine gloss that adds to the product appeal of the tartan designs employed. This was not possible with heated calender rolls.

Although the processing of artificial fibres is hardly within the scope of this meeting, the heat-setting of Nylon fabrics provides another indication of the importance of uniform processing heat, accurately controlled. Nylon has such a critical setting temperature that well set fabrics have been rare. Many of the major textile mills which are finishers of Nylon fabrics have therefore adopted this radiant heat for curing their woven and warp knit fabrics. Not only does it provide a uniform setting of the fabrics but it cuts the usual preliminary operations in half — at a considerable saving in handling costs. It is now possible for finishers to heat-set the fabrics after dyeing because the acetate colors are seemingly unaffected by this type of heat. This method has speeded operations to the extent that in some mills they accomplish in one shift what formerly required two-shift operations.

In the year just past, our company has developed a new type heater which we call the SupeRadiant heater — so named because of its higher temperatures. It has a range of temperature from 100° F. to 1000° F. and the diameter of the bore is varied to accommodate the diameter of the processed material. One application for this unit has been on the extrusion heads of plastic extrusion machines. This unit provides

uniform temperature at that important point on the machine and it is hotter, cheaper, faster and cleaner than oil systems. It offers many advantages over strip heaters, as well, for they lack uniformity of heat and entail high operating costs. Other uses for this type of heater will undoubtedly be developed.

The SupeRadiant heater in flat applications has found important uses on tanks that hold all types of fluid and semi-fluid materials. The problem here is to maintain these fluids throughout at even temperatures, some of which are critical in range. The SupeRadiant heater holds the entire mass at a constant temperature permitting uninterrupted flow at all times of the day or night.

Our company maintains a processing unit at its laboratory in New Jersey which is kept busy every day in the week by manufacturers whose technicians brings their major heat problems for solution. This unit provides one or two side heat, a variety of different coating heads, dip tank and most everything required to simulate production conditions. Here we are handling acrylics and acetates, thermoset and thermoplastic resins, coated or impregnated papers and fabrics, hot melts and latices, plastic film and woven plastics, sandpaper and linoleum, rubber and rayon, spun Nylon and venetian blinds, artificial leather and polyethylene printing.

Because of the unusual nature of the heat developed by the fibre glass Super-Heater, manufacturers have brought us all the $64 heating problems. We welcome all these along with the regular problems for these often point the way to future requirements of the plastics world for more and more and still more specialized heat.

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# EXTRUSION NEEDS

By M. S. GREENHALGH

GENERAL ELECTRIC CO., BRIDGEPORT, CONN.

Every development chemist, process, methods or manufacturing engineer who is connected with the extrusion in any form of either plastic or rubber compounds is cognizant of the need for proper and efficient extrusion equipment. One of the reasons why both rubber and plastics have been referred to above is because there is no doubt that these materials are becoming more and more closely related. In addition a goodly portion of the knowledge of extrusion equipment has been based on experience with rubber compounds.

Since the advent of vinyl compounds, the extruding business has grown by leaps and bounds. We have progressed from the old rubber extruder to the extended, double extended, and multi-barreled versions—from the old food chopper screw to the torpedo, constant pitch, diminishing types prevalent today.

At the same time, improvements have been made on the plastic compounds themselves. Today we have faster and easier processing resins. It is necessary that we take full advantage of these resins for economical reasons. The technique of feeding the extruder in many cases has changed from mill-fed to granulated and finally to powder mix. Pigments, lubricants, fillers and plasticizers, together with the base resin or compound, are being added directly in the extruder. In short, the extruder is being required to perform tasks which hitherto have been performed in various types of mixing equipment.

M. S. GREENHALGH

There are, however, many questions still unanswered as to what is the proper and most efficient extruder design. It is felt by many that the equipment manufacturer has not kept abreast of the needs of industry. Perhaps, it is also the fault of industry itself for not properly presenting the problem on a cooperative basis to the equipment manufacturer.

This need not only covers the fundamental design of the extruder itself, but also a design which would be more efficient from a manufacturing standpoint of simplification of operation by the factory operator. It is not the intent of the author, at this time, either to state his opinions or attempt in any way to solve the various problems presented in this paper. Rather, the purpose is to present these problems so that they might be brought to the attention of the manufacturer. It might be that he is already aware of these troubles but does not realize the extent to which they plague the processor.

In starting with the fundamental design, there is no doubt in any one's mind that the heart of the extruder is the screw. Yet today, there is hardly any agreement throughout the industry as to what is the best type. By type is meant single or double pitch, shallow or deep cut, constant or diminishing depth, angle of pitch, width of pitch, blunt, knobbed or torpedoed and last but not least the overall length. How many times upon ordering an extruder has one been informed by the manufacturer that the machine includes a "standard screw"? Just what is a standard screw?

Not so long ago, the author personally inquired of a representative of one of the larger and more prominent extruder manufacturers why a certain type of screw was delivered as standard equipment. The author was informed that confidentially the representative did not know. It had been his experience that this particular type of screw, to his knowledge, had never satisfactorily been proven and in many cases, he hesitated even to recommend it. It is felt by many that more of an engineering study has been made on the study of an agitator of a domestic washing machine than on the screw of an extruder.

The screw, important as it is, is not the whole answer. There is one important point which has been almost totally unnoticed despite the fact that it has been recognized any

number of times as being the reason why a certain type of screw gave a good performance in one machine and not in another, although the extruders were supposed to be identical to each other in every respect. This is the clearance between the screw and the barrel or sleeve. One can go into a great deal of theorizing on what the exact clearance should be and why. It is sufficient to say that there seems to be an optimum clearance which should be both practical and efficient from the standpoint of maintenance and operation.

In discussing the clearance and taking into account any slippage or scrubbing action which might be desirable, the finish of the screw and the sleeve must be considered both from the standpoint of aiding in the frictional action and preventing decomposition of the plastic compound. Should either the screw or sleeve be plated or made from a special alloy?

Sometime ago there was a test run made at the author's plant in Bridgeport whereby two extruders with different types of feed holes were evaluated on a test run. One of these machines had a center feed which consisted of a circular hole directly over the screw, while the other machine had a rectangular side feed. The results obtained on this particular run were quite surprising. Yet we have the same standardization of feed holes by the manufacturer as we have in the case of screws.

One basic difference between plastic and rubber extrusion is the use screens in a plastic setup. The answers as to how many holes and the size of holes a breaker plate should contain and whether or not they should be tapered have never satisfactorily been answered. Furthermore, the space between the end of the screw and the breaker-plate is quite important, and this variable has never definitely been established.

In considering the breaker plate, one has to take into account the screens. Nothing in the extruder is varied quite so much as the screens. Naturally this is so because of the ease and economy with which these screens changes can be made. There is much confusion as to what mesh screens, the number and how they should be placed. One thing is certain, if the screw is not performing correctly by not delivering the required amount of plasticized compound varying the screens will not mean a thing.

Travelling down the extruder from the feed hole, the next item is the head. The straight away extruder does not have the problem that the cross head extruder has. In common the size and internal contour of the head is most important. This is particularly true for the cross-head where the direction of flow of the compound is changed to the extent of 90 degrees. It is quite interesting to note the manner in which the Germans attempted to solve this problem during the last war by designing straight away heads together with nippled screws and also 45 degree cross heads. Both of these ideas were used for insulating wire with thermoplastic materials.

In most cases where cross head extrusion is being done, a centering device is employed. There are numerous problems concerning its use but most of these are purely mechanical, and the complaining usually comes from the operator of the extruder. Therefore, this problem will be discussed under manufacturing design.

The final items under the fundamental design are the heating and cooling facilities which might be available. Most of the extruders are heated by either oil or steam. Of late, there have been a number of electrically heated extruders on the market. This is by far the easiest and cleanest method of heating. However, all electrically heated extruders should be provided with proper methods of cooling due to the fact that these extruders have a tendency to overheat or override particularly with vinyl compounds. This last point is very important, because it was brought out beyond any doubt that internal working of the compound in the extruder was causing heat build up which hitherto had been overlooked because the steam and the oil was not only heating the extruder but also preventing overheating. This was further proven by the fact that some of the original designs for electrically heated extruders did not provide any cooling facilities. Decomposition of the compound was usually the result. It is quite evident, from the above information, that not too much is known of the heat history of a compound as it flows through the extruders. Perhaps finer and more accurate control of both heating and cooling is needed.

As previously stated, it is felt by many that the design of the extruder from the standpoint of actual factory operation could be improved. Most of the complaints on this score come from either the operator or the foreman. One has only to go back a few years to remember the cumbersome head changes. Today most of heads are on hinges, but improvements still could be made. In a number of cases the extruder has bolts and nuts which are hard to get at, heads which are hard to clean, breaker plates which jam, hoppers which do not stand-up under constant use, etc.

In the case of centering devices for cross head extrusion, there is room for much improvement. The standard four bolt method is not satisfactory by any means. Broken bolts which have to be drilled out, barked knuckles, and chewed die holders are certainly good evidence to substantiate this. Some attempts have been made to overcome this by different designs. They have not been fully proven out. The principle of both the self-centering nylon setups and the Western-Electric self-centering heads is certainly an improvement.

It is the hope of many processors to have a design particularly for cross head extrusion whereby the operator will not have to keep ducking underneath that which is being extruded in order to operate the machine. It is preferred that the operator remain on the head side of the extruder and by the proper placement of a panel board containing instruments, controls, etc. operate the tuber from that position eliminating the need of the ducking referred to above.

There is one objection which is not a true function of the design on an extruder and that is non-standardization of designating the various sizes of extruders. Such a standardization by the various manufacturers would certainly aid industry.

One might think, after taking into account all of the problems previously discussed, that it is just short of a miracle that any extrusion is being done at all. It is the feeling of the author, however, that if one is close enough to the extrusion process one will have no trouble substantiating these problems and most likely could elaborate on them to some length. Further proof of this is the number of heated discussions in which the author has taken part over the last decade.

In attempting to overcome some of the aforesaid difficulties, there have been designed entirely new types of extruders, for example, the Mill struder (National Rubber Machine) and the double parallel screw extruder (Welding Engineering, Inc.). These machines were designed somewhat to overcome a number of the present extrusion troubles. In addition the machines are better able to process new plastic compounds to-

gether with variations of the mixing techniques of existing plastic compounds.

In summarizing, the most important need of the plastic extrusion industry is a more efficient design of screw which would take into consideration the importance of clearances. When this has been done then the major problem will have been solved, and the other problems such as heating and cooling, design of head and etc. can be undertaken based on the above results.

# RAW MATERIALS FOR THE PLASTICS INDUSTRY

By GILBERT THIESSEN
KOPPERS CO., INC., PITTSBURGH, PA.

The plastics molding and fabricating industry is unique in that its raw materials are, in themselves, highly manufactured products. Any increase in supply of such materials depends upon the growth of specialized chemical manufacturing industries which stand between them and the ultimate raw materials.

The necessary raw materials for the present plastics industry were made available by the two World Wars. Large volumes of inexpensive synthetic phenol and a background of newly acquired experience in its production were provided by World War I. In the 'Twenties the new and growing radio industry offered an outlet for phenol as phenolic resins.

World War II caused the erection of huge facilities for large-scale production of styrene to be used for the production of synthetic rubber. The end of the War and the replacement of much of the synthetic rubber with natural rubber supplied large quantities of styrene monomer at low cost. Also, much new knowledge about polymerization techniques was acquired during the War under the intensive research of that period. Tonnage production of polystyrene was the result.

## WHAT IS THE PLASTICS INDUSTRY?

The plastics industry produces synthetic resins and molds them. Fabrication of synthetic resins into fibers (textiles) and coatings (paints, varnishes, and lacquers)* is not usually included in any consideration of the plastics industry. However, these uses compete for the same ultimate raw materails and add to the manufacturing volume with resultant lower unit manufacturing costs. Thus, any discussion of raw materials for the plastics industry must consider the raw materials requirements of the synthetic organic coatings and fibers industries.

The most important plastics and synthetic resins are:

| | |
|---|---|
| Cellulosics | Vinyls |
| Phenol-Aldehydes | Polyethylene |
| Urea-Aldehydes | Polystyrene |
| Acrylics | Nylon |
| Alkyds | |

## CELLULOSIC PLASTICS

Historically, the nitrocellulose plastics are the oldest. They are rapidly decreasing in importance. Two major manufacturers of them have recently announced discontinuance of their manufacture.

The raw material requirements for the nitrocellulose plastics are cellulose, nitric and sulfuric acids and camphor for plasticization. These raw materials are widely available, and since this plastic is declining in importance, raw material requirements offer no problems.

- Cellulose acetate flake or equivalent
  - Cellulose
  - Acetic anhydride or equivalent
  - Caustic soda
  - Acetone
- Plasticizer
  - Phosphorus oxychloride
  - Cresols
  - Phthalic anhydride
  - Octyl alcohols
  - Nonyl alcohols
  - Butyl alcohols
  - Ethyl alcohols
  - Hydrogen chloride

Cellulosics have recently declined in importance. Cheap polystyrene with its better resistance to moisture was the principal reason.*

## PHENOLICS

At present, the most important synthetic resins as a group are the phenolics. Phenolic molding powders, laminating and coating resins, adhesives and casting resins sold in 1948 amounted to 376 million lbs., or about 25% of the 1.48 billion lb. synthetic resin total. Until 1949, the most important molding compounds were the phenolics. In that year, the consumption of polystyrene molding powders rose to about 170 (est.) million lbs. exceeding for the first time the consumption of phenolic molding powders which dropped during that year to about 105 (est.) million lbs.

The raw materials required for phenolic resins are:

- Phenol or equivalent
  - Benzene
  - Sulfuric acid
  - Chlorine
  - Caustic soda
- Formaldehyde
  - Methanol
  - Methane, ethane, propane, or butane
  - Air or oxygen
- Fillers and re-inforcers

Prior to World War I, all U. S. phenol production was from natural sources. Wartime demands for picric acid required the erection and operation of synthetic phenol plants, and the end of the War found the country with a "war surplus" of over 40 million lbs., equal to six years normal requirements. However, the rapid growth of the phenolic resin industry used up this surplus in three years and forced erection of new synthetic phenol plants.

Today the still expanding synthetic phenol production is more than ten times the production of natural phenol, which is at its practical maximum. Competition and research have made phenol available in ever-growing quantities at a price which allows little room for further decline. Even with the succession of synthetic processes — sulfonation, chlorination, and Raschig — there still remains the elusive goal of slipping inexpensive oxygen from air between a hydrogen and carbon in the benzene ring by direct oxidation, although a plant using such a process did operate for some time. During the last war, the supply of phenol was insufficient to meet demands and was, therefore, rationed. Shortness of supply was due to lack of sufficient plant capacity rather than lack of raw materials. Since the war, a number of new plants have been built and put into operation and phenol is again available in quantities to meet all present requirements.

Benzene is the essential raw material by any process now used. Production of the 274 million pounds of synthetic phenol in 1948 required 32 million gallons of benzene, or about 20% of the total available. More will be said about benzene supply and demand in the discussion of polystyrene.

The quantity of cresols available at present prices is limited by the amount available in coke-oven tar plus those recovered from petroleum cracking products (**Chemical Indus-**

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* All production or consumption values for 1949 are estimates based on statistics for the first nine months of 1949.

tries, Jan., 1947, p. 48).

At present it is not possible to synthesize cresols at prices competitive with the cost of the natural cresols or with phenol. Synthetic para-cresol is listed at 50c per lb.; synthetic phenol at 12.5c per lb. Higher prices for cresol supplies can usually be afforded by manufacturers of plasticizers, chemical products and disinfectants. These greatly reduce the already small supply of cresols and xylenols for the plastics industry. As cresol alternatives for modified resins the industry uses alkylated phenols such as para-tert-butyl-phenol, para-tert-amyl-phenol, para-phenyl phenol and similar products made from synthetic phenol. Recently the iso-propyl phenols have been made available at prices slightly above those for the cresols. These more nearly approach the cresols than do the other alkyl phenols mentioned above.

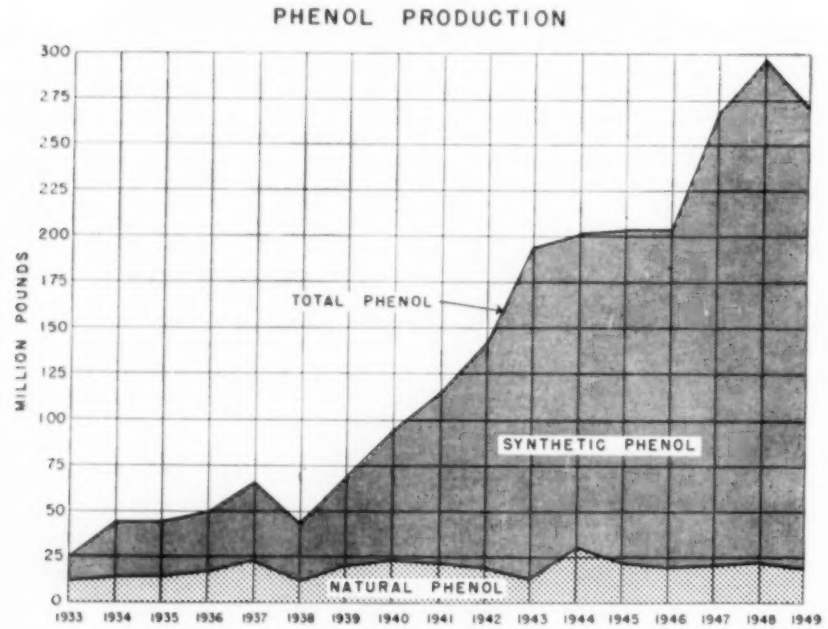
Will there be other sources of cresols in the future? There are three possibilities: (1) synthesis from toluene; (2) "low-temperature" coal-carbonization; and (3) coal liquefaction by hydrogenation. The first still seems remote in view of the large amount of effort spent on the problem in the past. Occasionally rumor has it that the problem of low-cost cresol synthesis has been solved but, so far, none has come on the market.

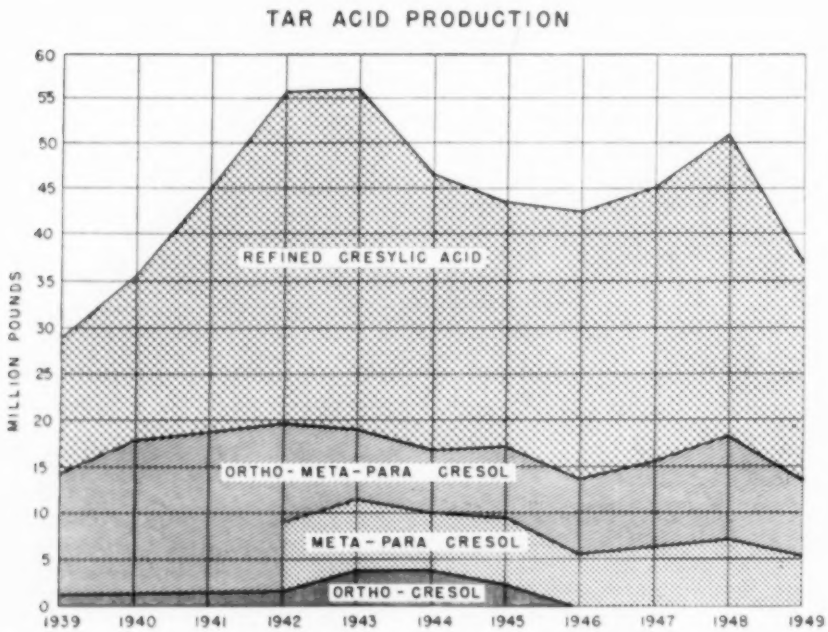
The second possibility, that of "low-temperature" carbonization, is looking up again. With increased pressure for smoke control in our larger cities in which high volatile bituminous coals are important domestic fuels, "low-temperature" carbonization of coal may increase in extent. One major unit is just now coming into full production.

The third possibility, while remote in time, is very definite. Hirst, Skinner and Donath* have recently estimated that a 30,000 barrel per day hydrogenation plant using 12,500 tons of coal per day would produce 1,330 barrels or 467,000 pounds per day of phenol, cresols, and xylenols. This is about 2% of the coal charged. Estimates as high as 5% and even 8% for some high oxygen coals have previously been made. Contrast this with the less than 0.2% of tar acids recovered during high temperature carbonization. Further, let it be remembered that the 200 barrel per day hydrogenation plant recently completed by the United States Bureau of Mines as a demonstration plant, i.e., a big pilot-plant, if operating steadily, could produce about 1 million pounds of tar acids per year.

The average daily run to stills of petroleum in the United States is about 5 million barrels. If coal hydrogenation is becoming even a small factor in our liquid fuel supply, the quantities of tar acids available will be of an entirely different magnitude than we have today. Both industry and Government are spending large sums in a study of this problem.

Formaldehyde is the other major chemical raw materail for phenolic resins. It, together with methanol, can be made either by direct partial oxidation of the $C_1$, $C_2$, $C_3$, and $C_4$ hydrocarbons with air or oxygen, or it can be synthesized from a mixture of carbon monoxide and hydrogen. This mixture can be prepared from water gas or from natural gas. Methanol is readily converted to formaldehyde by direct air oxidation. Why, then, were methanol and formaldehyde in short supply? The units in which synthetic methanol are made must be large in order to be economical. Investment is large and a continuing market must be in sight. Construction of new plants was restricted during the war because of the large amounts of specially fabricated steel presure vessels they required. Synthetic ammonia plants were built instead. Equipment




* Hirst, L. L., Skinner, L. C. and Donath, E. E., "Improvements in Hydrogenation of Coal," U. S. Bureau of Mines, Information Circular 7486, Dec. 1948, pages 5 and 6.

* Hirst, L. L., Skinner, L. C., Clarke, E. A., Daugherty, R. W. and Levene, H. D., "Estimated Cost of Producing Heavy Fuel Oil by Hydrogenation of Coal," U. S. Bureau of Mines report of Investigation 4413, Nov., 1948, pages 7, 15, 26-27, 29 and 42.

synthetic ammonia plants can quite readily be converted to methanol production and such conversions were planned for the post-war period. However, the increased need of the world for fertilizer nitrogen shifted these plans. With rising demands for formaldehyde due to increased availability of phenol after the war, the situation was further aggravated by accidental damage to some operating units. War and post-war troubles now have been eliminated and formaldehyde is again in ample supply.

### UREA AND MELAMINE RESINS

These products also require urea or melamine, and formaldehyde about which we have just spoken. The raw materials are:

Urea
- Ammonia
- Carbon dioxide

Formaldehyde
- Methanol
- $C_1$-$C_4$ Hydrocarbons
- Air or oxygen

Urea is made from ammonia and carbon dioxide and only plant capacity should limit supply. Although urea is of increasing interest as a fertilizer and cattle food adjunct, a large proportion of production is available for plastics (**Chemical Industries**, April, 1949, p. 559).

Melamine is made from calcium cyanamide, which in turn is made from calcium carbide and nitrogen. Calcium cyanamide is made principally for fertilizer markets and should, therefore, be an ample supply for plastics production. The limitation here, if any, is plant capacity for the conversion of calcium cyanamide to melamine.

### POLYSTYRENE

Only styrene monomer is required for polystyrene production. The monomer is made from benzene and ethylene, and of these benzene is required in the largest weight ratio. The 377 million lbs. of styrene monomer produced in the United States in 1948 required approximately 40 million gallons of benzene. Styrene monomer and phenol account for the major portion of the 170 million gallons of benzene now used in the United States. Distribution of available benzene among uses for 1944 and 1947 were estimated to be as follows:

| Product | 1944 Gallons Allocated (Millions) | 1947 Gallons Used (Millions) |
|---|---|---|
| Aviation Gasoline | 130 | nil |
| Styrene | 50 | 37 |
| Phenol | 25 | 32 |
| Nylon | 8 | 18 |
| Aniline | 13 | 13 |
| Maleic Anhydride | 1 | 3 |
| Synthetic Detergents | 1 | 3 |
| Miscellaneous Chemicals | 18 | 40 |
| Solvents | 6 | 10 |
| Export | nil | 2 |
| Unaccounted for | nil | 7 |
| TOTAL | 252 | 165 |
| BENZENE PRODUCED | 188 | 165 |

Most benzene comes from the high temperature by-product oven carbonization of bituminous coal. About 1.8 gallons are available per ton of coal coked. Because the chemical industry is growing faster than the by-product coke industry, which is tied to the steel industry, demand in the chemical industry has nearly caught up with supply. Thus there has been a continuing shift of benzene from motor fuel and solvent markets into the chemical industry and a tendency toward price increases.

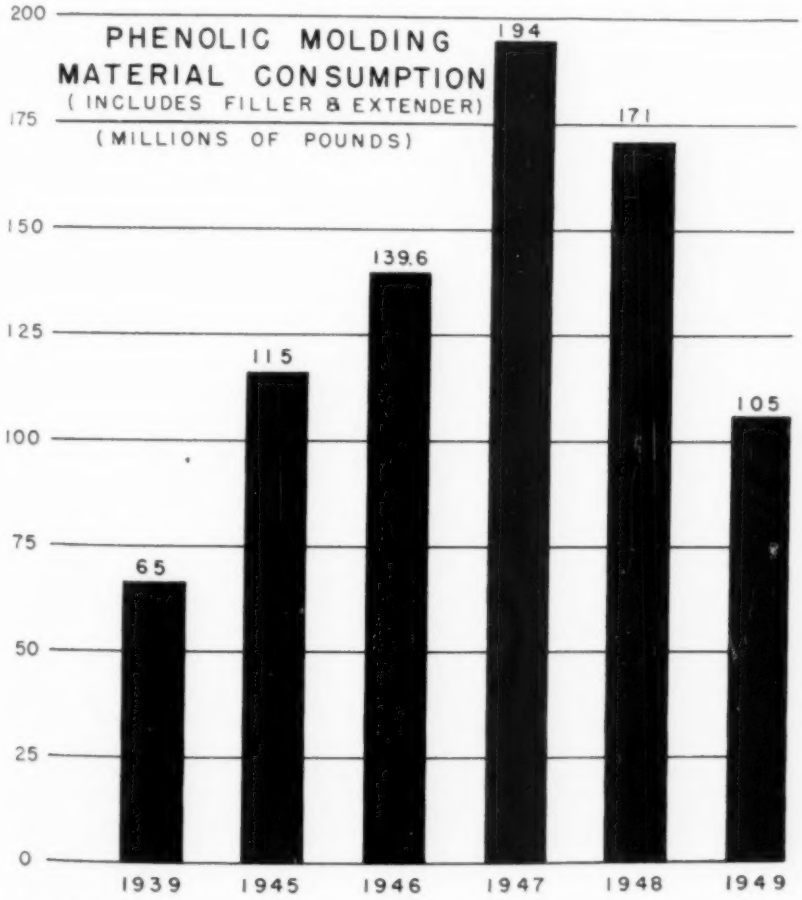
Production of GR-S synthetic rubber during the war placed an unprecedented drain on benzene supplies. About 25% of GR-S is styrene and at the peak of production about one million tons per year were made. Nineteen forty-eight production was some 400,000 long tons and 1949 production may be 350,000 tons. With fluctuations of this magnitude reflected in styrene and further in benzene demands, the effects are of an entirely different magnitude than are fluctuations in benzene requirements for purely chemical uses. Barring any upward change in GR-S production, as some have predicted would follow the introduction of "cold" rubber, the benzene supply situation is now easy.

Alternative benzene sources are petroleum and coal hydrogenation. At present prices, production of benzene from petroleum will be moderate but an unprecedented demand might make it profitable to recover large amounts of benzene from petroleum.

Just what this price differential must be has not yet been definitely established but it appears to be greater than ten cents per gallon over present prices.

Coal hydrogenation as a source of benzene is now, of course, only a prospect. But if a national synthetic liquid fuel program is undertaken and coal hydrogenation is selected as one of the processes, large quantities of benzene could be made available.

Ethylene can be made by dehydrating ethyl alcohol, ethyl ether or by hydro-carbon cracking. Because it is a gas which is difficult to liquefy, transportation for great distances is rarely practical. Ethylene is usually



made on the spot, or plants using it are near large petroleum cracking plants where great quantities are available as a by-product of gasoline manufacture. Ethylene and its close relatives — propylene and acetylene — have grown in importance to the extent that they now far outshadow the coal-carbonization raw materials in volume and value of products made from them. In versatility and number of products, the "coal-tar" products still hold supremacy.

As long as petroleum products are freely available, there need be no concern about raw materials for ethylene.

### POLYETHYLENE

This plastic requires only ethylene — very pure ethylene — for its manufacture. From a raw materials supply standpoint, therefore, there should be no practical limit to the availability of polyethylene.

### VINYL RESINS

For the vinyl resins, ethylene and acetylene are key raw materials. Their availability is limited only by the capacity of facilities for producing them. Raw materials used are:

Resins
- Acetylene
- Ethylene
- Hydrogen cyanide
- Hydrogen chloride
- Chlorine
- Acetic acid
- Ethylene oxide
- Acetone

Plasticizers
- Phosphorus pentoxide
- Cresol
- Phthalic anhydride
- Sebacic acid
- Ethanol
- Butanols
- Octyl alcohols
- Nonyl alcohols

The vinyl resins are like the cellulosics. Plasticizers are an essential ingredient. Vinyls are not very useful by themselves. They must be compounded with viscous high boiling liquids having the correct properties to yield tough useful products. Because of the large volume of the vinyl resins and their requirements for plasticizers, a sufficient supply of suitable plasticizers is and will continue to be a growing problem of the vinyl resin industry. These plasticizers are mainly esters, the most important of which are the cresol and related esters of phosphoric acid and the alkyl esters of phthalic acid, for example, tri-cresyl phosphate, dibutyl phthalate, diethyl phthalate and dioctyl phthalate. The phosphates give flame-resistant compounds and the phthlates give low-temperature properties and have a low initial cost. The critical materials in each case are cresol and phthalic anhydride. Phthalic anhydride is made largely from naphthalene. The only alternative source is the moderately available petroleum ortho-xylene. Thus both the phosphates and phthalates are independent upon the coal-carbonization industry.

The future availability of cresols was discussed under Phenolics. Phthalic anhydride is also in demand by makers of alkyd resins, largely for protective coatings and by the chemical industry for dyes and other products.

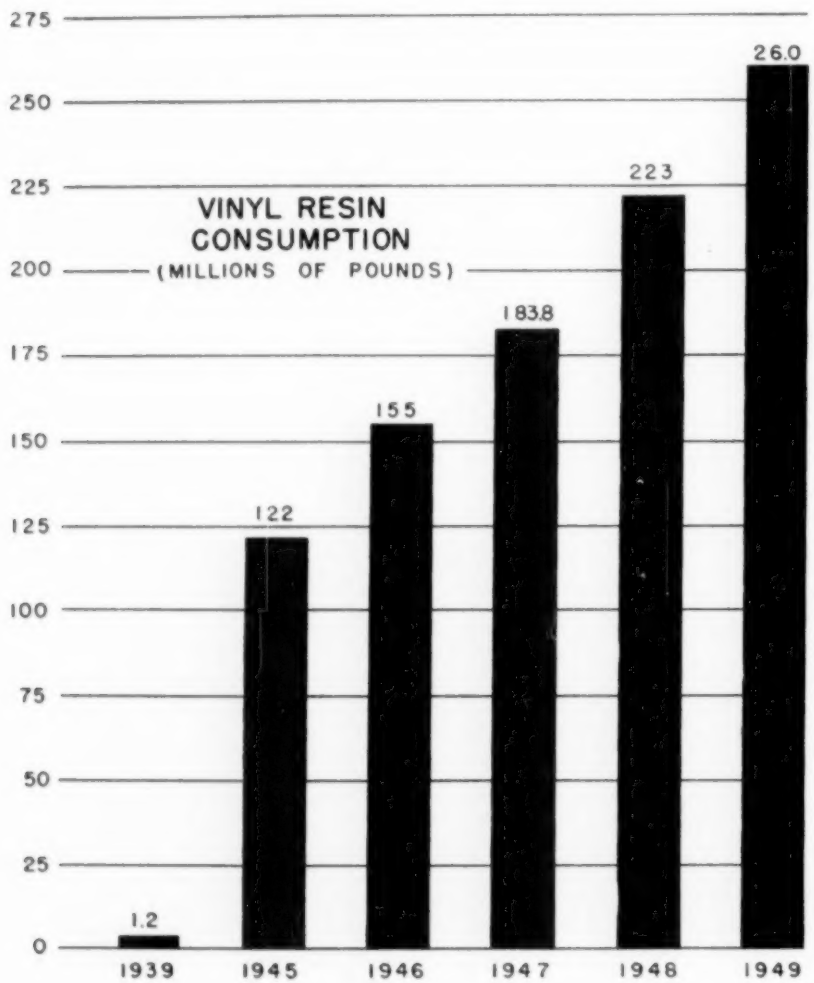
For some ester plasticizers the availability of the alcohol has, in the past, been the limiting factor. Such limitations now seem to have been eliminated.

### ALKYDS

At present the alkyd resins find only a minor use as plastics. But there is some promise of an increase in this use (**CI, Oct., 1946, p. 589**). They and their modifications, on the other hand, find extensive use in the protective coatings field. The raw materials are:

- Phthalic anhydride
  - Naphthalene
  - O-Xylene
- Maleic anhydride
  - Crotonaldehyde
  - Benzene
  - Naphthalene
- Glycerol
  - Propylene
  - Fats and oils
- Penterythritol
  - Formaldehyde
  - Acetaldehyde
- Drying oils
- Styrene
  - Benzene
  - Ethylene

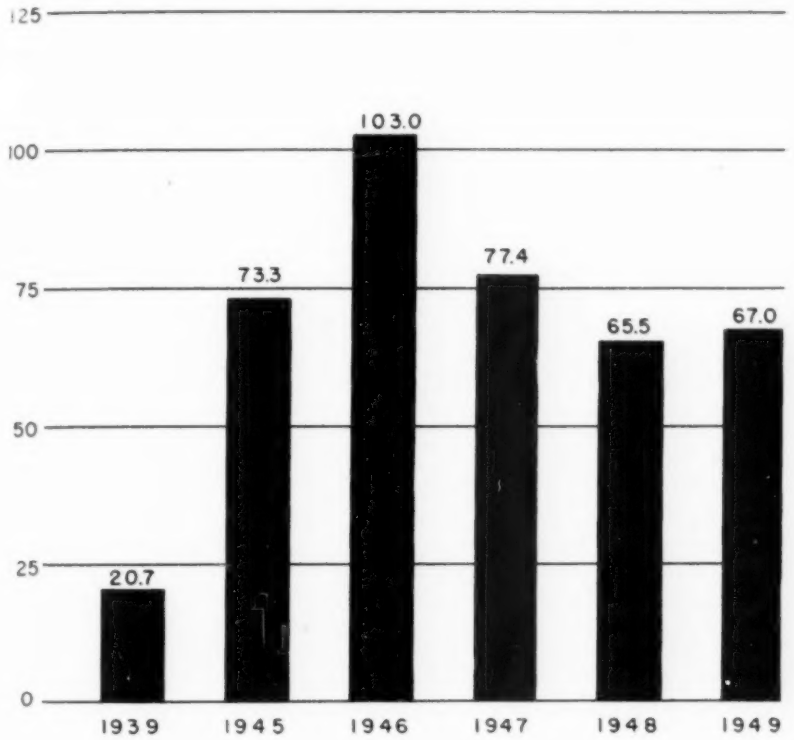
Their interest here is because of their competition for certain raw materials which are also of importance to the plastics industry, namely phthalic anhydride, phenolic compounds and, recently, styrene monomer. The alkyd resins have exceptionally good qualities for protective coatings, and it is stated by some that their use is limited only by their availability. Their large phthalic anhydride requirement, illustrated in the following chart, has been a big factor in the growth of phthalic anhydride production and the consequent lowering of price due to large volume production.




**PHTHALIC ANHYDRIDE DISTRIBUTION OF USAGE**

| Product | 1944 Pounds Allocated (Millions) | 1947 Pounds Used (Millions) |
|---|---|---|
| Ester Plasticizers | 69 | 45 |
| Alkyd Resins | 38 | 62 |
| Dyestuffs | 11 | 20 |

**CONSUMPTION OF CELLULOSE ACETATE AND CELLULOSE ACETATE BUTYRATE**
(INCLUDES FILLER & PLASTICIZER)
(MILLIONS OF POUNDS)




| | | |
|---|---|---|
| Food, Drug, Miscellaneous | 4 | 8 |
| Export | 2 | 6 |
| TOTAL | 124 | 141 |

Phthalic anhydride, in turn, is the largest use for naphthalene, as the following chart shows:

**NAPHTHALENE DISTRIBUTION OF USAGE**

| Product | 1944 Pounds Allocated (Millions) | 1947 Pounds Used (Millions) |
|---|---|---|
| Phthalic Anhydride | 170 | 190 |
| Chemical Intermediates | 53 | 75 |
| Moth Repellents, Etc. | 22 | 30 |
| Other Uses | 14 | 21 |
| TOTAL | 259 | 316 |

For the long term outlook, there should be a continuing full demand for phthalic anhydride. However, the availability of naphthalene and o-xylene will put a ceiling on the amount available. Imported naphthalene (37.5 million pounds in 1948 and also substantial in 1949) and the use of o-xylene provided some relief. The trend toward increased production of phthalic anhydride in Europe will tend to reduce the amount of naphthalene available for export to the United States in the future. At present, not all orth-xylene available is being used for phthalic anhydride manufacture.

# Restricted Gating for Large Castings

By W. P. GOBEILLE
NASH-KELVINATOR CORP., MILWAUKEE, WISC.

During the last year, we have added several new machines in our plant. These machines did not cost us one cent, nor do they require any floor space. The machines I refer to are those we created, in effect, as a result of production increase which was gained through the use of conversion of all our existing molds to the restricted gate. Actually, however, this was not the prime purpose for our efforts to develop this technique. We were mainly interested in improving the quality of our parts. We produce primarily parts for our refrigerator plant. Most of these parts are molded in white Polystyrene. I shall confine most of my remarks to our work with this one material; however, we have had considerable success in using the same technique on butyrates, vinyls and acrylics. We had originally standardized on a very heavy fan gate. We were using large sprues and heavy runners in an effort to get maximum quality in our parts. We found that we were having quite a bit of trouble due to parts sticking in the mold, requiring excessive mold lubrication, cracking due to strains imposed in the molding operation, flow marks and long cycles as a result of the curing time required for the heavy sprues. We set up a development project on several jobs in order to evaluate the possibility of using a restricted type of gate. I would like to stress the importance of keeping detailed records because of the small order of the changes required.

In our development work, we ran into quite a few problems which had to be solved before we could be successful. We found that in many cases, we did not have adequate chamber heats or the control of those heats. It was necessary to add wattage to all of our chambers. Although I have never tested it, I do not believe that the restricted gate requires higher material temperatures but we required more heat input into the chamber as a result of the increased cycle which only became possible through the use of the small gate. We found that our means of controlling mold temperatures were inadequate, both in the coils which we had provided in the mold and in the equipment. We were not able to do much about the molds except in special cases but we did design our own equipment for maintaining very accurate mold temperature control. In

some instances, we found that a redesigned nozzle gave excellent results. Uniformity of section thickness in multi-cavity molds became quite critical. Even small variations from cavity to cavity gave us trouble.

One of the biggest problems encountered was selling the idea to the foreman and to the operators. We were very fortunate in that respect in that we had a very experienced foreman with an open mind. Many of the things that we asked him to do were contrary to the things that he had learned in his many years of experience in molding. We spent a great deal of time in our discussions with the foreman so that he would be fully apprised at all times of the results that we were hoping to gain.

The mold for an ice cream cabinet lid of modified polystyrene was originally built as a two-plate mold and later converted to the three-plate restricted gate mold. The shot itself weighs 43 oz. and is molded on a 40 oz. press with a double stroking plunger. We use a specially designed nozzle which has a separate heating band under instrument control. Fortunately, we had adequate cooling lines in this mold and we found that we could get improved results by running at relatively high mold temperatures. Our conversion to three-plate restricted gate gave very gratifying results and one-third was cut off the total cycle time. The parts released more freely from the mold, weld lines and sinks were greatly reduced and surface finish was definitely improved.

A refrigerator baffle pan, as an thin section, we had felt would be example of a large area piece with very difficult to fill correctly without cracks and warps. We have used two runners in gating this mold and we have a very excellent weld. Incidentally, we are running this part on a 40 oz. press with a machine cycle of 26 seconds.

An Across-the-Top Evaporator Door weighs 26 oz. We had discussed building this mold as a three-plate mold but ran into a number of difficulties because of the side scoring on all four sides. We used a very small center sprue and achieved our restricted gate effect in the nozzle. We have designed our own nozzle and find that we get very excellent results. We can get the optimum in cycle since the cycle time is dependent entirely upon the part itself and not on curing a large sprue.

One part has two cavities of an Evaporator Door which has been side gated. We had considerable problems with this part as a result of a variation in the typical wall section. We found it was necessary to provide considerable venting before this part would run successfully. Another interesting point is that we have eliminated a costly finishing operation. We had previously had to saw and sand our fan gates on the Evaporator Doors.

A two-cavity shot of a clear-refrigerator door which we call a "HI-HUMID" door is interesting because of the necessity to develop completely strain-free moldings. If this were not achieved, we would have excessive cracking in assembly. We rivet a hinge on one side and assemble a die cast handle across the front. We ran a development project on this, testing the parts in solvent in order to develop our optimum molding conditions for strain-free parts. This is an example of the ability of the restricted gate to produce large and strain-free castings.

All of our jobs at the present time are gated with our conception of the restricted gate technique. As you can see from these samples, the size of the sprue, runner and gate vary to some extent. We have been able to achieve the following improvements on our parts: greater strength, better surface finish, improved molding cycles and less finishing costs. It is our thinking that the restricted gate technique makes gating a mold a science rather than an art. It is my honest belief that there will eventually be standards covering gating of different types of parts with different types of materials. I think that some consideration should be given by the S. P. E. to assist in the development of standards that I believe will improve the quality of plastic parts throughout the industry without any sacrifice in cost.

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**Papers received too late for publication in this issue.**

## CHARTING NEW COURSES

By EDWARD J. WOHLFARTH,

*Mayflower Electronic Devices, Inc.*

This paper will review some of the case histories of articles made from plastics or using plastic materials for which Mr. Wohlfarth has built devices now in operation here and abroad. Some of the articles are: rainwear, shower curtains, table cloths, toys, lamp shades, paper bags, luggage, pocket books, sportswear, clothing, cloth labels.

The foregoing is not a complete list of the items on which he has done research. By the time of the conference he may be able to make certain announcements which may change the text of the paper.

## WHAT'S NEW IN MOLD MAKING

By L. J. MORRISON,

*Detroit Mold Engineering Company, Detroit, Michigan*

Part 1 — Machinery

Discussion of the trend toward larger die sinking machines such as Cincinnati Hydrotel's and more fully automatic machinery such as Gorton's new electric duplicator.

Part 2 — Heat Treating

A very short discussion on Lindberg's recent advanced bright hardening and the hardening of stainless steel.

Part 3 — Short discussion of the steels developed since the war specifically for plastic molds.

Part 4 — Discussion of the use of Sperry Reflectoscope for checking steel to be used in cavities.

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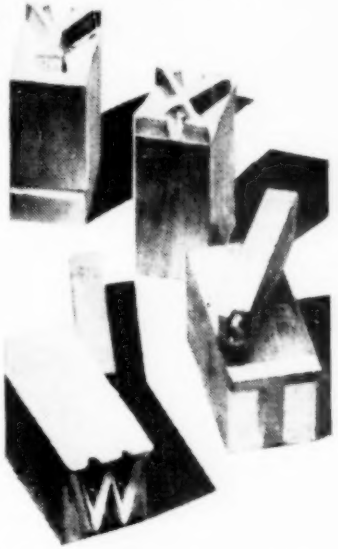

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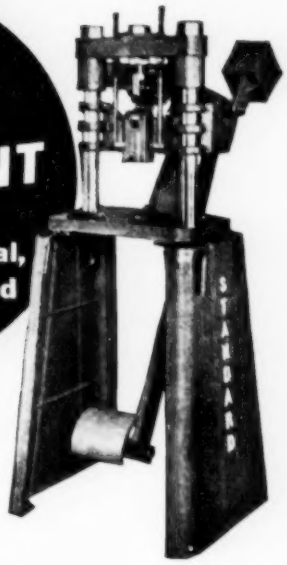


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## W. NEW ENGLAND

### By GEORGE W. MARTIN

The Western New England Section of the Society of Plastics Engineers held their regular meeting on Wednesday, December 7, 1949. The meeting, held at the Hotel Sheraton, Springfield, Mass., was presided over by Section President, Sherwood Young.

Secretary Ed Vaille, who has been doubling as both Secretary and Treasurer, presented his annual reports which showed a healthy membership of ninety, a gain of twelve in the past year. The section is in excellent financial condition as well.

Section President Young congratulated President-Elect Vaille and his new Board and Officers. He thanked the existing officers and committee chairmen for their assistance and for enabling him to have concluded a very successful year as President.

Mr. Young then turned the meeting over to the Program Chairman, Mario Petretti. Mr. Petretti had planned for the meeting a Symposium on Thermoplastics and Thermosetting Molding Techniques, design, tooling problems and trouble shooting.

Prizes were awarded for questions previously submitted and used on the program, with additional prizes for stumping the experts. The panel of experts consisted of: George Whitehead of Improved Paper Machinery Corp., Dick Richardson of DeBell & Richardson, Ed Vaille of Bakelite Corp., Paul Holmberg of Arrow Hart & Hegeman, Jack Cavanaugh of Standard Tool Co., John Resseguie of Tennessee Eastman Corp., and Mario Petretti of Rogers Plastics Corp., Moderator.

The evening proved to be entertaining, as well as educational, with several prizes being awarded.

Among the guests present were: Mr. J. H. DuBois of Shaw Insulator Co., Mr. W. Bracken of Hercules Powder Co., and Mr. S. Blitz of the Noma Electric Corp. (N. Y.)

## NEW YORK NEWS

### By A. M. MERRILL

Instead of its regular monthly technical meeting, the New York Section held a Christmas Party on December 21 at the Hotel Shelburne. Over 60 members and their guests attended the party which was a huge success and is expected to become an annual affair.

Following the dinner, outgoing president Stanley Bindman, Noma Electric Corp., reviewed the activities and achievements of the Section during the past year, and announced the new officers of the group, as follows: president, Sam Silberkraus, Riverdale Laboratories; vice-president, G. Palmer Humphrey, G. P. Humphrey Plastics; secretary-treasurer (re-elected), George Baron, Ideal Plastics Corp.; and national director (re-elected), Nicholas V. Fasano, Washington Molding Co.

Mr. Bindman also announced the results of the recent mail balloting for new directors of the group, including a fourth director to fill the unexpired term of E. V. Walsh. The new directors are: Leo Adenbaum, Accurate Molding Co.; B. A. Boucher, Durite Division, Borden Co.; C. W. Kleiderer, Arnold Brilhart, Ltd.; and W. A. Ward, American Cyanamid Co.

Mr. Silberkraus spoke briefly, praising the work of the outgoing officers and expressing his hope that the Section would continue to grow and improve during the coming year.

On behalf of the members, Mr. Silberkraus also presented to Mr. Bindman a token of esteem for his work on behalf of the Section: one used ski.

Table favors were distributed through the courtesy of Koppers Co., Inc., Monsanto Chemical Co., Tennessee Eastman Corp., and Renwal Mfg. Co. There was a drawing for 11 door prizes contributed by Durez Plastics & Chemicals, Inc., Celanese Corp. of America, Noma Electric Corp., Koppers, Monsanto, American Molding Powder, Tennessee Eastman, and Sylvan Plastics. The formal program concluded with the distribution of grab-bag prizes brought in by the members.

## SOUTH TEXAS

Results of the South Texas Section elections for 1950 are as follows: President, Charles E. Shepherd, Industrial Plastic Mfg. Co., 604 Willard St., Houston, Tex.; Vice-President: L. D. Blackwell, Blackwell Molding Co., Houston, Texas; Secretary-Treasurer, Willis L. Barnes, H. L. Thompson Co., Houston, Texas; National Councilman: Marion A. Arthur, Humble Oil & Refining Co., P. O. Box 2180, Houston, Texas; Directors: Charles E. Shepherd, L. D. Blackwell, Alfred Fukal, H. S. Henderson, Phil Shay, J. A. Sinclair, M. A. Arthur, W. L. Barnes, D. E. Henderson.


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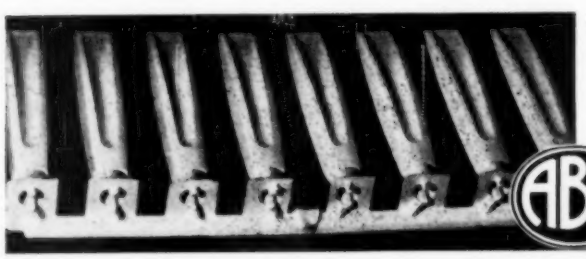

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